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EXPERIMENTAL INVESTIGATION OF THE VISUAL FIELD DEPENDENCY IN THE ERECT AND SUPINE POSITIONS

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16. Abstract

The increasing utilization of simulators in many fields, in addition to aeronautics and space, requires the efficient use of these devices. It seemed that personnel highly influenced by the visual scene would make desirable subjects, particularly for those simulators without sufficient motion cues. In order to evaluate this concept, some measure of the degree of influence of the visual field on the subject is necessary. As part of this undertaking, 37 male and female subjects, including eight test pilots, were tested for their visual field dependency or independency. A version of Witkin's rod and frame apparatus was used for the tests. The results showed that nearly all the test subjects exhibited some degree of field dependency, the degree varying from very high field dependency to nearly zero field dependency in a normal distribution. The results for the test pilots were scattered throughout a range similar to the results for the bulk of male subjects. The few female subjects exhibited a higher field dependency than the male subjects. The male subjects exhibited a greater field dependency in the supine position than in the erect position, whereas the field dependency of the female subjects changed only slightly.

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CONTENTS

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SUMMARY

The increasing utilization of simulators in many fields, in addition to aeronautic and space, requires the efficient use of these devices. It seemed that personnel highly influenced by the visual scene would make desirable subjects, particularly for those simulators without sufficient motion cues. In order to evaluate this concept, some measure of the degree of influence of the visual field on the subject is necessary. As part of this undertaking, 37 male and female subjects, including eight test pilots, were tested for their visual field dependency or independency. A version of Witkin's rod and frame apparatus was used for the tests. The results showed that nearly all the test subjects exhibited some degree of field dependency, the degree varying from very high field dependency to nearly zero field dependency in a normal distribution. The results for the test pilots were scattered throughout a range similar to the results for the bulk of male subjects. The few female subjects exhibited a higher field dependency than the male subjects. The male subjects exhibited a greater field dependency in the supine position than in the erect position, whereas the field dependency of the female subjects changed only slightly.

INTRODUCTION

The mounting complexity and cost of space vehicles, airplanes, and even ground level vehicles have led to an extensive increase in the use of simulator devices to gain information during the early design of the vehicle and also as a training aid. With this increasing use of both moving and fixed-base simulators to represent the various moving vehicles, it becomes important to learn those characteristics of the subjects which will influence man's response to the simulator and the results obtained so that a better understanding of the correlation between simulators and the real vehicles can be developed. This understanding may permit, from properly trained personnel, an advantageous selection of people for use as simulator test subjects. The extent to which the presented visual field interacting with other sensory cues affects the subject's performance may be one such selection characteristic. It was thought that those people who would be highly influenced by the visual scene potentially may make good simulator subjects, particularly for

simulators that are unable to provide adequate motion cues. A method of measuring this influence is to determine the extent to which the visual field influences the subject's judgment of the vertical. This influence by the visual scene, in the experimental psychology field, is called field dependency (fd) for subjects highly influenced by the field and field independency (fi) for those unaffected by the field (ref. 1). This type of measurement of field dependency or independency may also be an aid in interpreting the simulator results for the real application.

In reference 2, some data for a limited number (12) of essentially field dependent and independent Navy pilots indicated that field-independent subjects performed a tracking task better. However, the authors of reference 2 deduced that the field-dependent subjects were unduly influenced by the frame around the visual scene. The essential question was still unanswered, especially if the visual presentation covers a wide viewing field. Therefore, as part of the Langley Research Center's interest in efficient use of its simulators, a program has been undertaken to evaluate the field dependency of Langley test pilots who are frequently used as simulator pilots. Since personnel other than test pilots are used in the simulators, the program also included additional people, both female and male. When simulation data become available, application of these field-dependency data to analysis of the subject's performance of a calibrated simulation task should aid in evaluating the relative effectiveness of the field-dependent—field-independent people as simulation subjects.

Previous research has dealt with the concept that field dependency or independency is related to the way in which a person perceives his surroundings and even to his personality. (See, for example, refs. 3 to 12.) In reference 11, some results of fd-fi tests of airline pilots are presented. A careful study of the same literature in this discipline, however, has failed to show an explicit criterion for determination of whether a subject should be classified as field dependent or independent.

In the present study, besides measuring the fd-fi of the test subjects, an attempt was made to develop a method for determining the degree of a person's field dependency. If such a method is developed, it could be a useful tool in the selection of potentially the most promising test subjects for use in a simulation. To this end a version of Witkin's rod and frame apparatus (which is described subsequently in the paper) was used to measure the influence of the visual field on the test subject's estimation of the vertical. The tests were conducted with the subject in two positions: erect where both gravity and body cues are available, and supine where the gravitational cue is not an important factor and only the cue of body position is available for aid in alining the rod.

The data developed in the present investigation are potentially of considerable interest to personnel in the field of experimental psychology, in addition to their potential application to simulator activities.

EQUIPMENT

The equipment used for the present tests was a version of Witkin's rod and frame apparatus. This version differed from Witkin's basic apparatus in that the rod and frame were electrically driven and could be set at any desired angle between -45° and $+45^{\circ}$ by remote control, and the resulting angles can be read from remote meters. The essential features of the test equipment are shown in the sketch in figure 1. The two platforms, an upper platform hinged to a lower fixed platform, were 0.61 m (2 ft) wide and 2.44 m (8 ft) long and were made of 1.905-cm-thick $\left(\frac{3}{4}\text{ in.}\right)$ plywood with 4.13-cm-thick by 9.21-cm-wide $\left(1\frac{5}{8}\text{ in. by }3\frac{5}{8}\text{ in.}\right)$ rails along the sides for stiffness. The test chair was a transport pilot's seat, with about 15° of tilt in the backrest; the seat and the headrest support structure were rigidly fastened to one end of the hinged platform. The headrest positioned the head laterally in line with the rod so that the line of sight was perpendicular to the plane of the rod and frame. The drive mechanism and its support platform were mounted at the other end of the hinged platform. This left a viewing distance from eyes to rod of about 1.45 m $\left(4\frac{3}{4}\text{ ft}\right)$. Photographs of the subject in the test chair and the experimenter are presented as figure 2.

The reason that the two basic platforms were hinged was to permit the upper platform with the chair and drive mechanism to be tilted as much as 90°. A 7.62-cm-wide (3 in.) angle iron attached on each side to both the tilted and fixed platforms made a rigid triangular structure. This platform tilted up 90° is shown in figure 3.

The drive mechanism for the rod and frame is shown in figure 4. The drive motors were 115-volt ac motors driving through 2000-to-1 reduction gear boxes in order to get a reasonable slewing rate for the rod and frame. The outer drive shaft was a 2.54-cm-diameter (1 in.) hollow tube supported by ball bearings and controlled the position of the frame. The inner drive shaft was a 0.635-cm-diameter (1/4 in.) rod supported by ball bearings inside the outer drive shaft and controlled the position of the rod. Friction devices were incorporated to eliminate the tendency of the drive mechanisms, particularly the frame, to coast past the desired setting. Potentiometers also were geared to the drive mechanism to furnish the rod or frame position input for the remote meters. A plywood board was mounted behind the rod and frame to block the view and prevent any of this structure from providing an attitude cue.

The faces of the rod and frame were painted dayglow orange which fluoresced under ultraviolet light. The rest of the structure and mechanism was painted flat black or draped with black flannel to reduce the background visibility as much as possible.

The remote equipment is shown in figure 5. The dual power supply, seen in the background, supplied equal voltage to both sides of the potentiometer to provide equal

reading on both the positive and negative sides of the readout meters. The power supplies were set at about 100 volts dc to give a full-scale reading on the readout meters of $\pm 45^{\circ}$; with the null meter, it was easy to maintain the power voltage setting to within 1/2 percent. The two meters in the foreground are the readout meters; one meter presented the angular setting of the rod and the other meter presented the angular setting of the frame. These are 0-center meters and were calibrated so that they read $\pm 45^{\circ}$ for full-scale deflection. Battery-powered aircraft-type instrument lamps were mounted above each readout meter and the recording clipboard to furnish red light for the data recording in an otherwise totally dark room.

Ultraviolet light was furnished by the lamp seen behind the readout meter in figure 5. The aluminum tube around the lamp was installed to confine the stray ultraviolet light that might escape and cause other items, such as clothing, to fluoresce with a resulting increase in general background light intensity. A filter holder was built into the tube to hold the ultraviolet and neutral density filters which were used to select the desired rod and frame illumination.

Because of the relative rigidity of the drive mechanism, calibration of the frame was rather simple in that, for any angle of the frame, an inclinometer could be placed on its upper member and the angle read off directly. Because of the relative limber drive shaft for the rod, it was necessary to go to the more intricate reflected light system. This scheme (fig. 6) uses a small mirror mounted on the side of the rod to reflect light from a collimated source against the wall behind the light source. Lines marked on the wall designated the various angular settings of the rod.

The equipment was located in a totally dark room so that no visual cues other than the rod and frame were available to the subject even after extensive dark acclimation.

For the tests with the upper platform tilted up 90°, the ultraviolet light source of necessity was much closer to the rod and frame than it was for the tests with the upper platform horizontal. Tests were made with a photometer to determine the extra neutral density filters necessary to make the light intensity as nearly as possible the same for both sets of tests.

Control of the rod or frame was accomplished by two on-off instantaneous button switches, one for each direction. The experimenter had two pairs of switches for control of the rod and frame. The test subject had only one pair for control of the rod.

TESTS

Two sets of tests were conducted: "erect" position tests in which the platform was horizontal and the subject sat erect (fig. 2), and "supine" position tests in which the plat-

form was tilted up 90° and the subject was on his back (fig. 7). The erect position tests were made first because the erect position is more frequently encountered and was considered to be initially less disturbing to the subject.

The subject was brought into the test room under lighted conditions. After the subject was seated in either the erect or supine position, the lights were extinguished and the subject was allowed about 3 minutes to become dark acclimated to the totally dark room before the tests began. During this acclimation period, the subject was informed about the test. The rod and frame would be set at various angles to the vertical, sometimes at the same angle and sometimes at different angles, and the subject was to set the rod back to the vertical. For his purposes during the erect position tests, the vertical, which is actually the direction of local gravity, could be considered parallel to the corner of the room (i.e., the intersection of two walls). For the supine position tests, the subject was told to return the rod to a position that would be equivalent to the vertical in the erect position (body orientation). In this position the equivalent vertical could be considered parallel to the intersection of the adjacent wall and ceiling because the platform was set parallel to the wall. The subject was requested to close his eyes during the time the rod and frame were being set for each new pair of test angles.

The range of angles used for these tests was -45° to $+45^{\circ}$ for the rod and -40° to $+40^{\circ}$ for the frame. Fifty-five different rod and frame angle combinations were presented to each subject. Near zero, the angular settings were 2° apart and 5° apart for the rest of the range. For most of the tests, the rod and frame were set at the same angles; however, for some tests the rod was set at somewhat larger angles than those of the frame; for some tests the rod was set at smaller angles than those of the frame; and for some tests the rod was set at angles opposite to those of the frame. The same range of test angles, -40° to $+40^{\circ}$ for the frame and -45° to $+45^{\circ}$ for the rod, were presented to each subject. The order of presentation was a pseudorandom method whereby the experimenter arbitrarily selected an initial setting and then skipped around in the selection of successive points in order to avoid leading the subject. This method resulted in a different order of presentation for each subject. For most of the subjects, a total of about 60 points were obtained; some were check points when the data appeared inconsistent with those from the adjacent angles. In order to minimize any cue that would arise from the sound of the running motors while setting the angles, the general procedure was to run past the desired angle, then back down slightly past the angle again, and finally approach the desired angle setting. For each subject, these tests usually ran between 3/4 and 1 hour.

Thirty-seven subjects, ranging in age from 22 years to 52 years, were tested. The group consisted of 8 females and 29 males, with 9 of the males being pilots. The females were numbered subjects 1 through 8 and the males, 9 through 37.

Some abbreviated tests were made with the illumination on the rod and frame four times as bright as the normal illumination. These tests were made with 19 subjects only in the supine position.

RESULTS AND DISCUSSION

The data obtained for each subject from the erect and supine position tests are presented in appendix A. This large quantity of data was removed from the main body of the report in order not to intrude into the pertinent discussion of the results. However, an example of one set of representative data is presented in figure 8.

An inspection of the graphical presentation of the subject response in appendix A shows that even for this relatively small sample of 37 subjects, the data range from very high field dependency (fig. A7) to practically zero field dependency (fig. A28, erect position). However, for most of the subjects between these extremes, a similar pattern exists for their overall response. This pattern shows that, through the midportion of the response data, the frame exerts a nearly linear effect on the subject's response up to a certain angle (generally between 15° and 25°) which is referred to as the breakpoint. Beyond this angle, the influence of the frame generally decreases. In addition to this overall pattern, it is apparent that there is considerable variation in the results from subject to subject, in the value of the slope of the midportion of the data, in the angle considered the breakpoint, and in the manner of the response after the breakpoint (relative sharp break, gentle rounding, etc.).

Another point that should be mentioned is that for many of the individual subjects, there was often a considerable spread in the rod setting response to the same frame setting presented to him during the tests. The spread in response to the frame setting usually was not large for the lower frame angles; however, at the higher angles, the response spread quite often was as large as 6° to 8° and, occasionally, much larger.

The current method used to evaluate field dependency (ref. 5, for instance), generally is to measure the response of the subject at one frame angle, say 28°, and to separate the subjects according to the magnitude of their answers. Those subjects with the higher values would be classified as field dependent and those with the lower values would be classified as field independent. The data obtained in this investigation, however, indicate that probably the most important field dependency characteristic is the slope of the response data followed by the breakpoint.

Theoretically, the curve of a completely field-dependent person would have a slope of 1 – that is, the subject's response in locating the rod would be identical with the angle of the frame; whereas, the curve of a completely field-independent person would have a

slope of 0 – that is, the subject's rod response would be the same no matter what the angular setting of the frame. The slope, therefore, is an indicator of the influence that the field exerts on the subject; the breakpoints, on the other hand, indicate how far this influence extends. This suggests, therefore, that a criterion for describing a person's dependency on the visual field should include the slope and breakpoint information and maybe even the standard deviation. A choice of response at a single angle, particularly if the angle is beyond the breakpoint value, could lead to an entirely different conclusion from that of the choice of response at an angle only a couple of degrees away.

The slope discussed subsequently in the paper is the slope of the best-fit straight line through the data for the response of the rod against the tilt of the frame. The best-fit straight line was obtained by an unweighted least-squares procedure. The best-fit straight line was computed for the bands of frame deflection varying from $\pm 2^{\circ}$, $\pm 4^{\circ}$, up to $\pm 40^{\circ}$. The variation of the data from the line ($1 - R^2$, where R is the correlation coefficient) was also computed. The line which was a combination of the largest spread and the smallest value of $1 - R^2$ that best represented the data was considered the best-fit straight line. The angle spread considered here may not necessarily be the same as the breakpoints mentioned previously. This is a result of the nature of the data at these angles. Near the breakpoint, there is generally a larger variation in the results for each angle than at the lower angles. Consequently, the magnitude of the variation exhibited by the term $1 - R^2$ is larger and the exact breakpoint is ill defined; thus, some latitude is permitted in the choice of the angle used for the breakpoint.

Erect- and Supine-Position Characteristics

Histograms of the slope data obtained for both the erect and supine positions are presented for all the subjects, the males, the females, and the pilots in figures 9 to 12, respectively. The data for both positions are presented together in order to facilitate comparisons that are made later in the discussion. Histograms of the breakpoints are similarly presented in figures 13 to 16. The data in these figures show that the test population, in general, does not divide itself into groups strongly influenced or weakly influenced by the visual field but varies through a broad range. It appears that the test population is biased somewhat toward field independency more so in the erect position than in the supine position, as indicated by the median point falling at a slope value of 0.25 and 0.35 rather than 0.50 (fig. 9), and that the population is approximately normally distributed about this biased value. Extrapolating these data to the population in general infers that it would be normally distributed about some value slightly biased toward field independency, the large bulk of the population exhibiting a mild form of field dependency and only those subjects near either end of the distribution exhibiting the typical field dependency-independency characteristics (i.e., high slopes with moderate to high

breakpoints (fig. A7) as opposed to low slopes with small or no breakpoints (fig. A28). The histograms of the erect position for the various groups reveal two interesting facts. The slopes for the eight females tested (fig. 11) were generally among the highest of the test population; this indicated a somewhat greater tendency to be influenced by the visual field. The data for the nine pilots (fig. 12), eight of whom were test pilots, showed a distribution that was generally very similar to that for all the male subjects. This fact was somewhat surprising in that it was originally surmised that the pilots would probably be less field dependent than the males in general.

The effect of putting the subject on his back (which position decreases the effect that the gravity cue has on the subject's ability to discern the vertical) can be evaluated by comparing the supine position results with the erect position results (figs. 9 to 12). Comparison of these data shows that for the male subjects, pilots included, placing them on their backs increased their dependence on the visual field. On the other hand, the female subjects showed no appreciable change in field dependence. This effect of position is summarized in the following table in terms of the mean slope for the various groups:

Group	Slope for erect position	Slope for supine position
Females	0.48	0.49
All males	.21	.34
Pilots	.20	.35
All subjects	.28	.38

The data thus far have been presented for specific groups (i.e., females, males, pilots); however, the data in figure 17 show the change in slope for each individual subject. When the subjects were seated erect, occasionally the comment was made that it was difficult to judge the local vertical accurately and that confidence in their answers was low. When the subjects were tilted on their backs, this comment was almost universal. Lack of confidence was the result of somewhat greater orientation confusion. This was manifested in the greater scatter in the data, which can be seen in the graphical presentations in the appendix and which is summarized as standard deviation σ from the best-fit straight line in the following table:

Group	Standard deviation σ, deg, for –	
	Erect position	Supine position
Females	1.3	2.0
All males	1.1	1.8
Pilots	1.2	1.5
All subjects	1.1	1.8

A comparison of the data from the different illumination tests (a brightness ratio of 4 to 1) was made for about one-half of the subjects in the supine position only. These comparisons varied from good to bad. The results are shown in table I for a general order of fd-fi ranking, slope, and standard deviation. The order is that based on the information discussed in the next section (and shown in table III). This ranking showed that the subjects rated relatively field dependent were less influenced by the illumination level than those considered relatively field independent. For the field-independent subjects, generally the slope between breakpoints increased and the standard deviation from the straight line was somewhat smaller.

Comparative Rankings

In view of the data presented in the previous sections, it appears that a definitive method for determining the related field dependency or independency should include the slope, breakpoint, and variation data. However, it appears that application of the field-dependency information to simulator operation can be divided into two areas. If the simulator has a rather limited motion, say $\pm 15^{\circ}$ or less, the essential field-dependency parameter that is applicable is the slope. The breakpoints, usually occurring at larger angles, probably have only a minor influence. If, on the other hand, the simulator has large angular displacements, greater than $\pm 15^{\circ}$, then both the slope and breakpoint must be considered.

The method of evaluating field dependency for the limited angular displacement by using only the slope data was compared with the generally accepted method for determining field dependency. This generally accepted method for determining field dependency from rod and frame tests is to use the mean value of the angle at which the subject considers the rod vertical when the frame is tilted 28° off the vertical. Unfortunately, the present tests do not have values at a frame displacement of 28°; however, by assuming a linear variation between 25° and 30° and averaging these values, an approximate value representing $27\frac{1}{2}^{\circ}$ should be obtained.

The information presented in tables II and III for the erect and supine positions, therefore, are comparisons of the ranking of the test subjects from field dependency to field independency according to slope and according to a representative angle of $27\frac{1}{2}^{\circ}$. The comparative rankings presented in table II for the erect position show that for those subjects who were either highly field dependent or independent, the relative positions are about the same. At the top of the table for the highly field-dependent subjects, this agreement is due to the fact that the subjects' high slopes result in large values for $27\frac{1}{2}^{\circ}$, even though this angle is beyond the breakpoint. At the bottom of the table, the field-independent subjects have such a low slope that none of the values are large. In the

center of the table for the group where the response for a large frame angle is highly dependent on both the slope and breakpoint, there is considerable shuffling of the relative rankings. The data in table III for the supine position show even large scrambling of the ranking than for the erect position.

In the supine position, the influence of gravity on the vestibular and proprioceptive system no longer aids in the orientation of the local vertical; this is probably an important cause of the greater indecisiveness of the subjects, which results in larger variation in responses. Comparison of the relative ranking in this position with past research and the $27\frac{1}{2}^{\circ}$ test criterion seems tenuous, since the relative influences of the remaining proprioceptive senses and visual senses are not yet well known.

CONCLUDING REMARKS

An investigation was conducted to study the ability of people to determine the vertical under the influence of a tilted background (measure of the field dependency or independency of the subject). A rod and frame apparatus was used and the subjects were tested in both an erect position and a supine position to evaluate the contribution of the gravitational cue.

The results of the tests for both positions showed that the population, rather than dividing into field-dependent and field-independent groups, ran the gamut from those weakly influenced by the field to those strongly influenced. Almost every subject, to some extent, was influenced by the tilted field. The pattern of influence was nearly universal in that the subject followed the tilt of the field linearly up to some angle beyond which the tilted field had no additional influence. It appears, therefore, that determination of a subject's field dependency should include the slope and breakpoint information.

Comparison of the results obtained for the subjects in the supine position with those for the subjects in the erect position showed that, in general, the subject's ability to detect the equivalent of the vertical deteriorated in the supine position as exemplified by the larger standard deviations in this position. The male subjects as a group showed a loss in field independency when tilted over on their backs. On the other hand, the females as a group showed very little effect.

The question as to whether field-dependent or field-independent people would potentially be better subjects for use in simulators utilizing visual fields was largely left unanswered. The fact that the test pilots' results were about the same as those of the

general male group gave no hint from that direction. In addition, the necessary information that rates simulator subjects' performances in a good-bad scale is unavailable for comparison with the field dependency tests at the present time.

Langley Research Center,
National Aeronautics and Space Administration,
Hampton, Va., August 14, 1972.

REFERENCES

1. Asch, S. E.; and Witkin, H. A.: Studies in Space Orientation. I. Perception of the Upright With Displaced Visual Fields. J. Exp. Psychol., vol. 38, no. 3, June 1948, pp. 325-337.
2. Benfari, R.; and Vitale, P.: The Relationship Between Vertical Orientation in the Rod and Frame Test and Vertical Orientation in a Compensatory Tracking Task. Res. Dep. Mem. RM-2603, Grumman Aircraft Eng. Corp., Jan. 1965.
3. Asch, S. E.; and Witkin, H. A.: Studies in Space Orientation. II. Perception of the Upright With Displaced Visual Fields and With Body Tilted. J. Exp. Psychol., vol. 38, no. 4, Aug. 1948, pp. 455-477.
4. Witkin, H. A.; and Asch, S. E.: Studies in Space Orientation. III. Perception of the Upright in the Absence of a Visual Field. J. Exp. Psychol., vol. 38, no. 5, Oct. 1948, pp. 603-614.
5. Witkin, H. A.; and Asch, S. E.: Studies in Space Orientation. IV. Further Experiments on Perception of the Upright With Displaced Visual Fields. J. Exp. Psychol., vol. 38, no. 6, Dec. 1948, pp. 762-782.
6. Witkin, H. A.; Lewis, H. B.; Hertzman, M.; Machover, K.; Meissner, P. Bretnall; and Wapner, S.: Personality Through Perception. Harper & Bro., c.1954.
7. Barrett, Gerald V.; Thornton, Carl L.; and Cabe, Patrick A.: Cue Conflict Related to Perceptual Style. J. Appl. Psychol., vol. 54, no. 3, June 1970, pp. 258-264.
8. Matheny, W. G.; Dougherty, D. J.; and Willis, J. M.: Relative Motion of Elements in Instrument Displays. Aerosp. Eng., vol. 21, no. 5, May 1962, pp. 1041-1046.
9. Witkin, Herman A.: The Perception of the Upright. Sci. Amer., vol. 200, no. 2, Feb. 1959, pp. 50-56.
10. Cullen, John F.; Harper, C. R.; and Kidera, G. J.: Perceptual Style Differences Between Airline Pilots and Engineers. Aerosp. Med., vol. 40, no. 4, Apr. 1969, pp. 407-408.
11. Barrett, Gerald V.; and Thornton, Carl L.: Cognitive Style Differences Between Engineers and College Students. Perceptual & Motor Skills, vol. 25, 1967, pp. 789-793.
12. Schwartz, Daniel; and Karp, Stephen A.: Field Dependence in a Geriatric Population. Perceptual & Motor Skills, vol. 24, 1967, pp. 495-504.

TABLE I. - DATA FROM THE BRIGHT AND NORMAL ILLUMINATION TESTS

Subject	fd-fi ranking[a]	Slope			Standard deviation from best-fit straight line, deg		
		Bright lighting	Normal lighting	Difference in slope	Bright lighting	Normal lighting	Difference in standard deviation
10	4	0.34	0.35	-0.01	2.45	2.39	0.06
30	5	.58	.45	.13	1.30	2.09	-.79
2	6	.42	.45	-.03	2.18	1.35	.63
29	8	.43	.45	-.02	2.71	1.43	1.28
3	11	.50	.37	.13	4.12	1.30	2.82
33	13	.50	.30	.20	2.18	1.75	.43
14	14	.32	.45	-.13	1.75	1.75	0
31	17	.25	.38	-.13	3.28	1.55	1.73
12	18	.402	.45	-.05	2.50	3.98	-1.48
5	19	.10	.15	-.05	2.51	2.35	.16
18	23	.38	.33	.05	1.48	1.70	-.27
17	25	.35	.30	.05	2.05	2.43	-.38
13	27	.53	.20	.33	1.25	1.62	-.37
15	28	.28	.28	0	1.90	1.75	.15
4	29	.42	.25	.17	1.80	3.52	-1.72
16	30	.30	.26	.04	1.49	1.70	-.26
24	34	.15	.14	.01	1.33	2.10	-.77
25	35	.15	.14	.01	1.48	2.61	-1.13
34	36	.48	.10	.38	1.90	2.55	-.65

[a]This ranking is the same as that in table III for the supine position.

TABLE II.- COMPARATIVE RANKING OF FIELD DEPENDENCY OF TEST SUBJECTS IN ERECT POSITION AS MEASURED BY THE SLOPE METHOD AND THE $27\frac{1}{2}^{\circ}$ CRITERION

fd-fi ranking[a]	Slope method	$27\frac{1}{2}^{\circ}$ criterion
1	7	7
2	3	4
3	4	3
4	6	6
5	8	8
6	2	18
7	20	20
8	5	37
9	23	16
10	32	32
11	12	12
12	30	23
13	19	30
14	26	2
15	37	31
16	31	17
17	29	29
18	16	22
19	18	10
20	33	5
21	11	14
22	10	19
23	17	33
24	14	35
25	21	11
26	22	26
27	35	9
28	1	13
29	24	15
30	9	24
31	25	1
32	27	25
33	15	27
34	13	36
35	36	21
36	28	28
37	34	34

[a]The most field-dependent subjects are at the top.

TABLE III.- COMPARATIVE RANKING OF FIELD DEPENDENCY OF TEST SUBJECTS IN SUPINE POSITION AS MEASURED BY THE SLOPE METHOD AND THE $27\frac{1}{2}^{\circ}$ CRITERION

fd-fi ranking[a]	Slope method	$27\frac{1}{2}^{\circ}$ criterion
1	7	7
2	19	30
3	8	22
4	10	12
5	30	23
6	2	2
7	32	18
8	29	29
9	11	14
10	37	31
11	3	19
12	1	32
13	33	10
14	14	4
15	6	15
16	22	8
17	31	16
18	12	26
19	5	35
20	21	33
21	23	37
22	20	17
23	18	3
24	26	1
25	17	20
26	35	11
27	13	34
28	15	13
29	4	6
30	16	25
31	28	21
32	27	5
33	36	36
34	24	24
35	25	27
36	34	28

[a]The most field-dependent subjects are at the top.

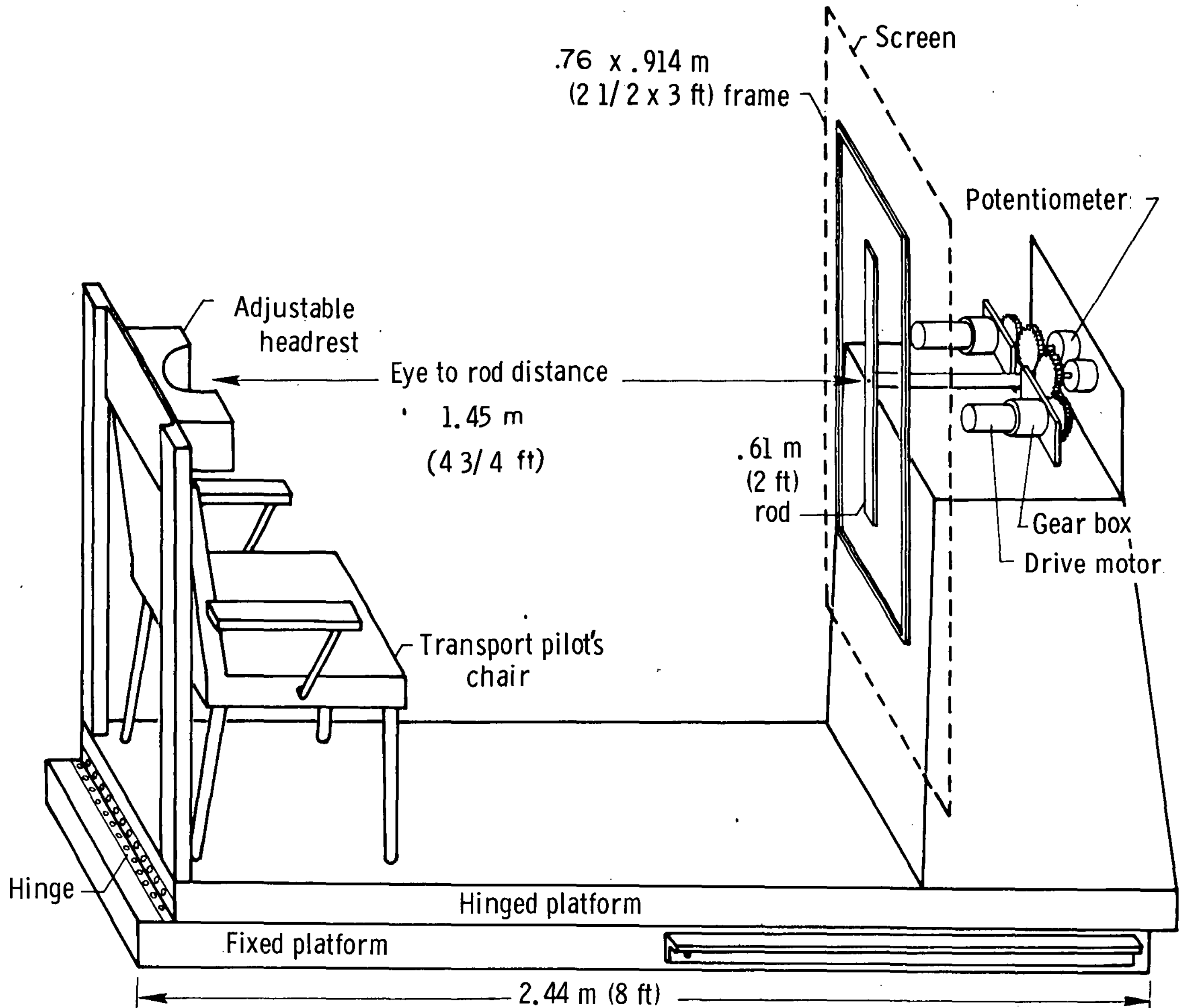
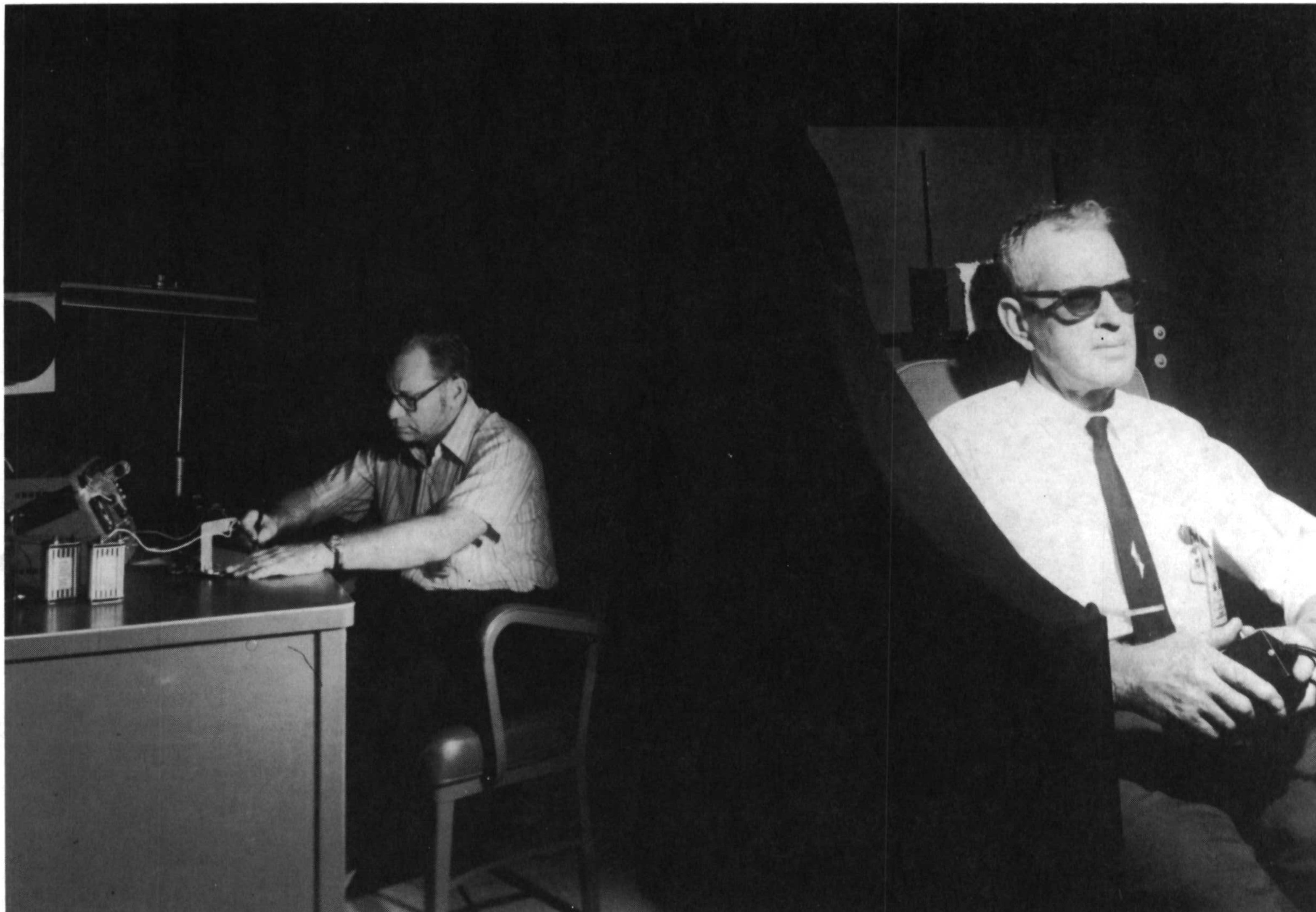


Figure 1.- Sketch of test equipment for field dependency measurement.

L-71-7050

(a) Seated test subject.

Figure 2.- Test setup for the erect position.



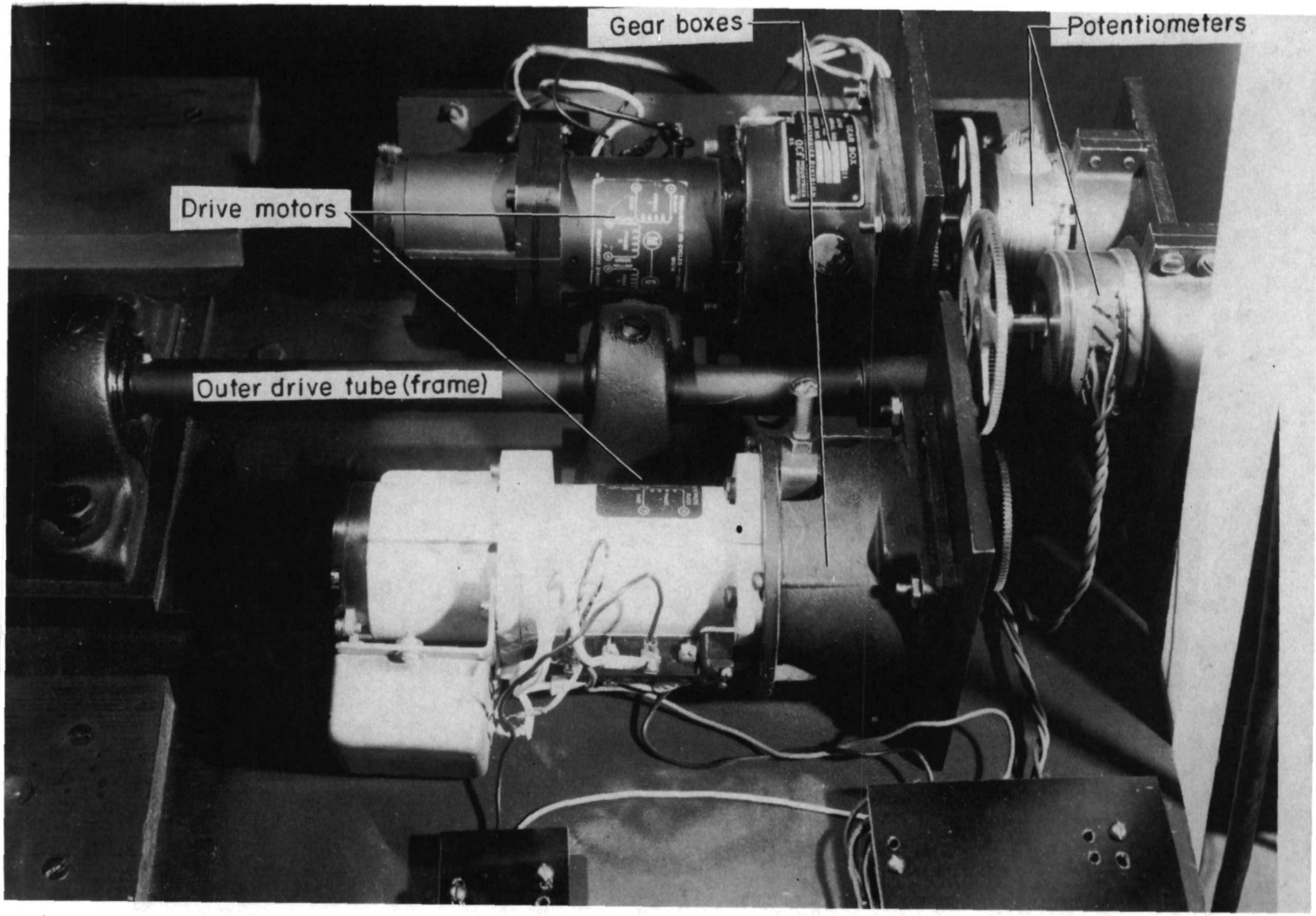
L-71-7049

(b) Relative locations of the test subject and the experimenter.

Figure 2.- Concluded.

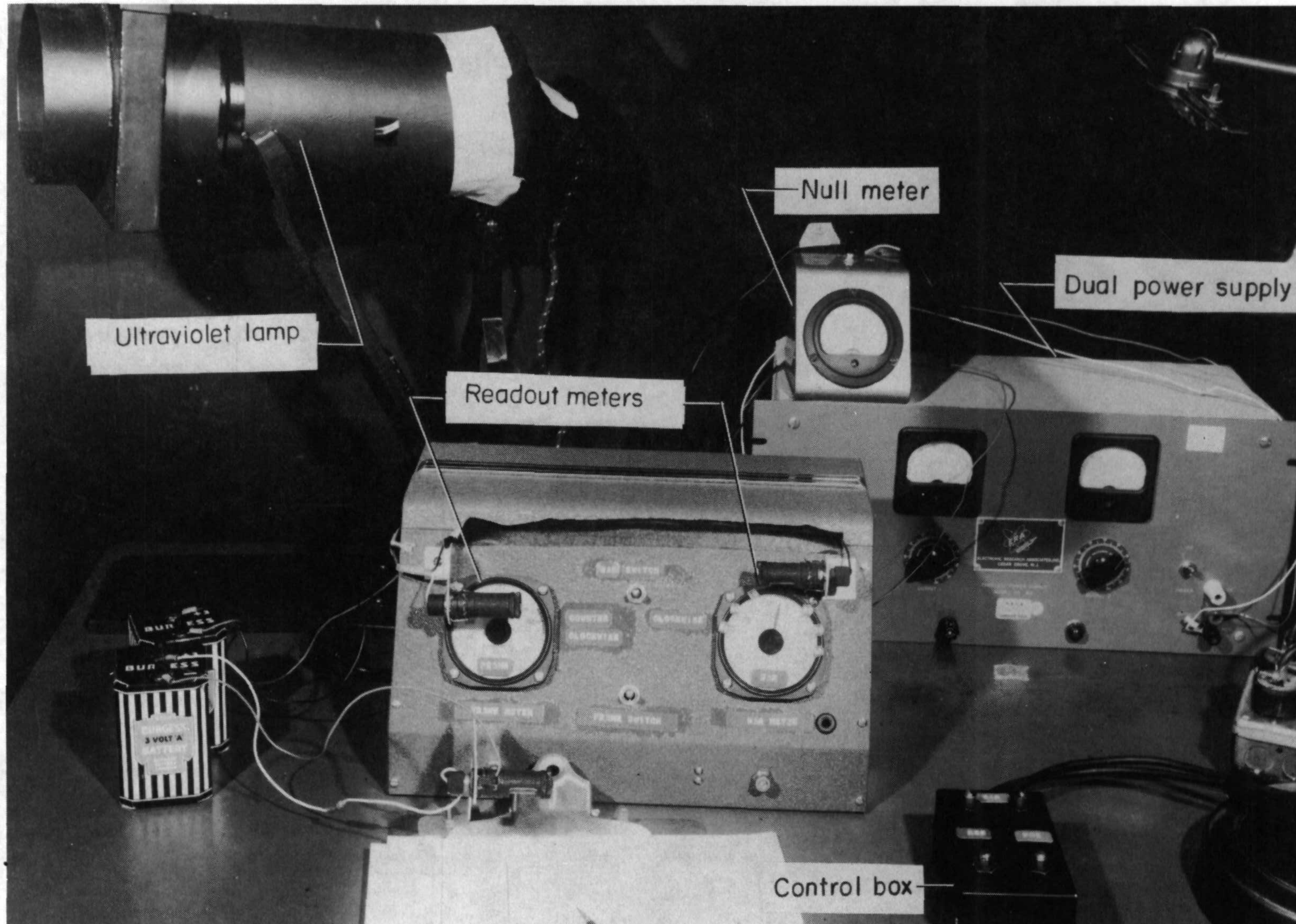
L-71-5169

Figure 3.- Test setup for the supine position.



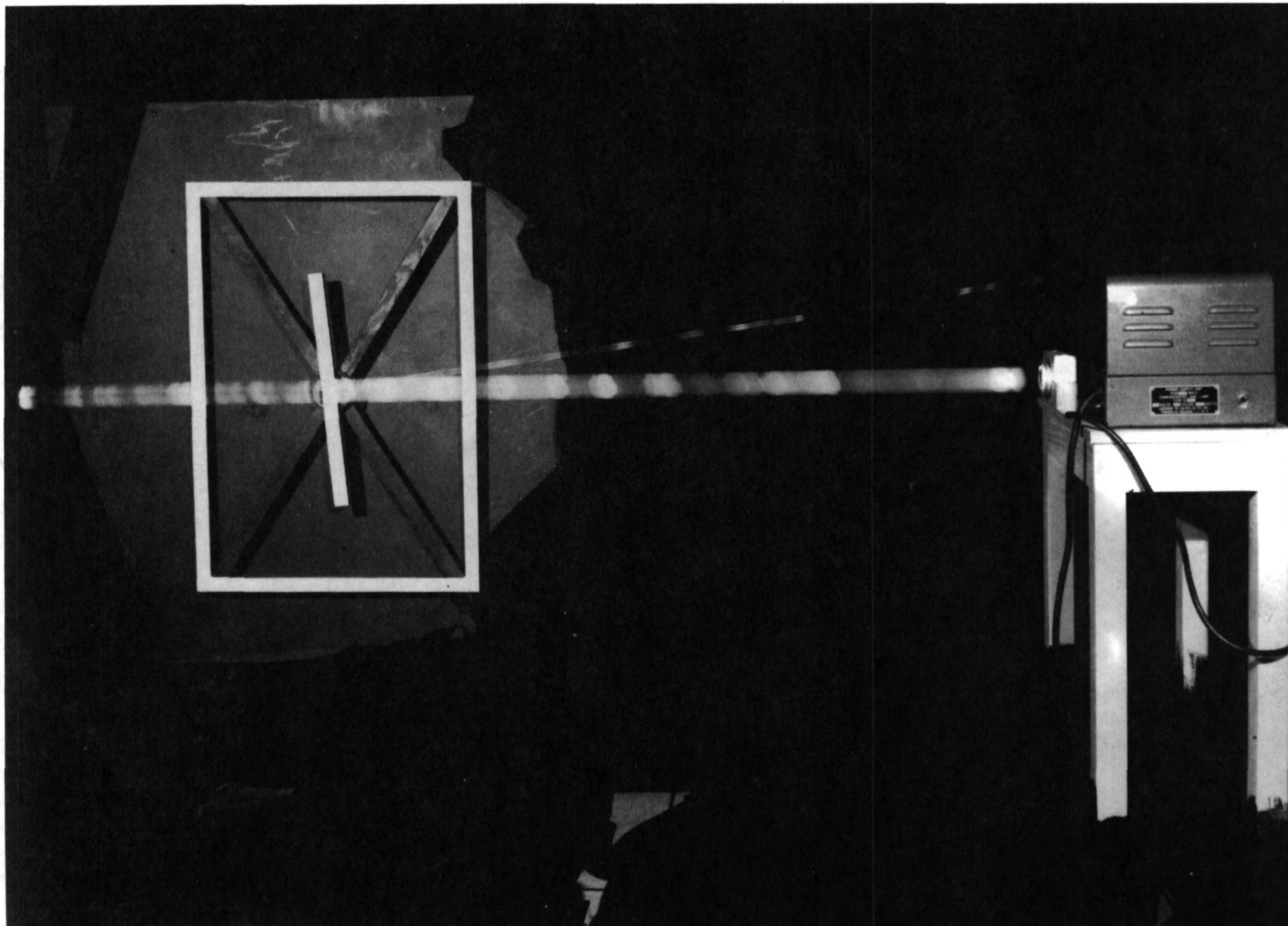
L-71-7053.1

Figure 4. - Drive mechanism.



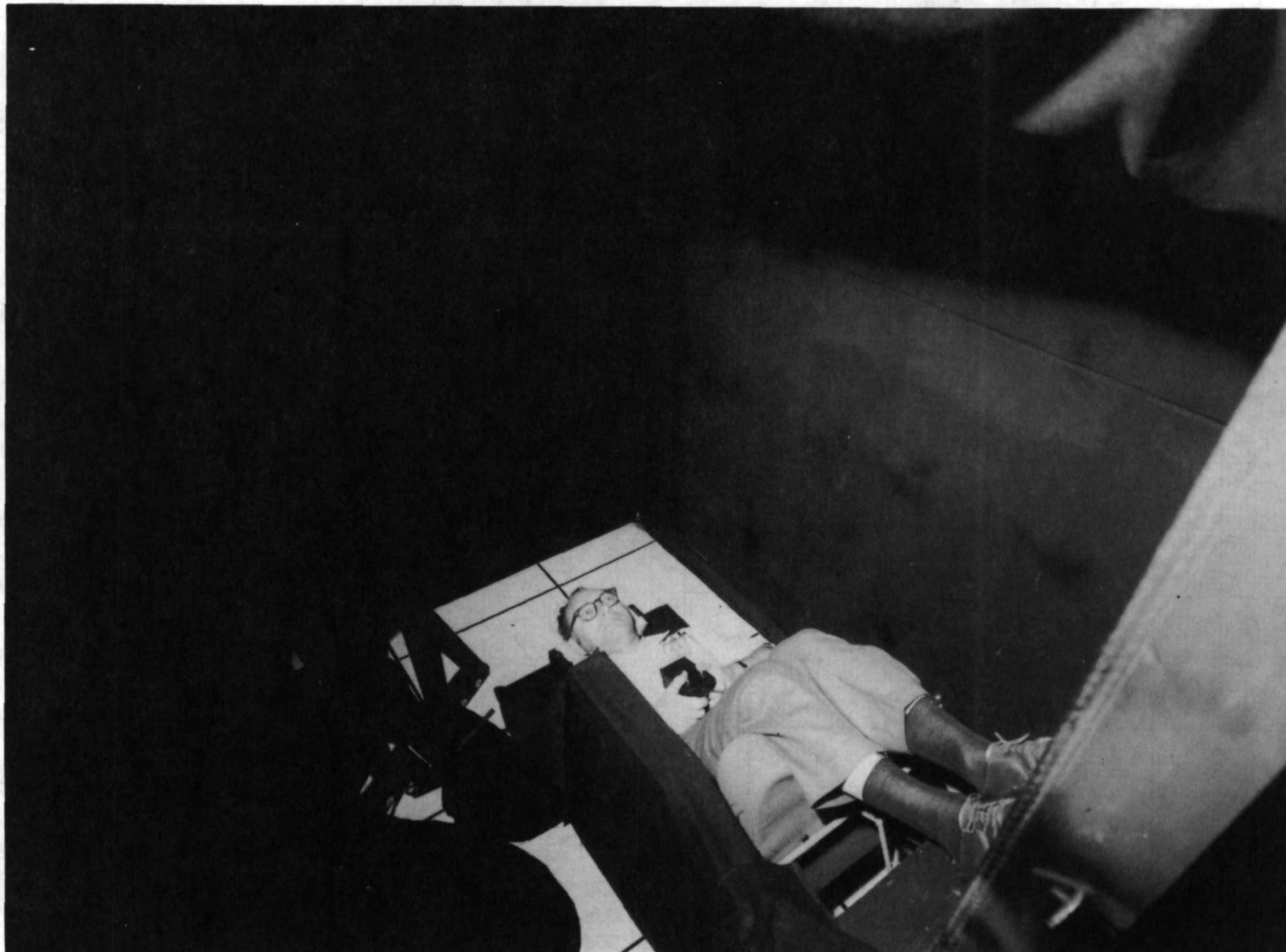
L-71-7054.1

Figure 5.- Instrumentation and ultraviolet light source.



L-71-7051

Figure 6.- Collimated light method of calibration for the rod.



L-71-5171

Figure 7.- Test subject in the supine position with the control box.

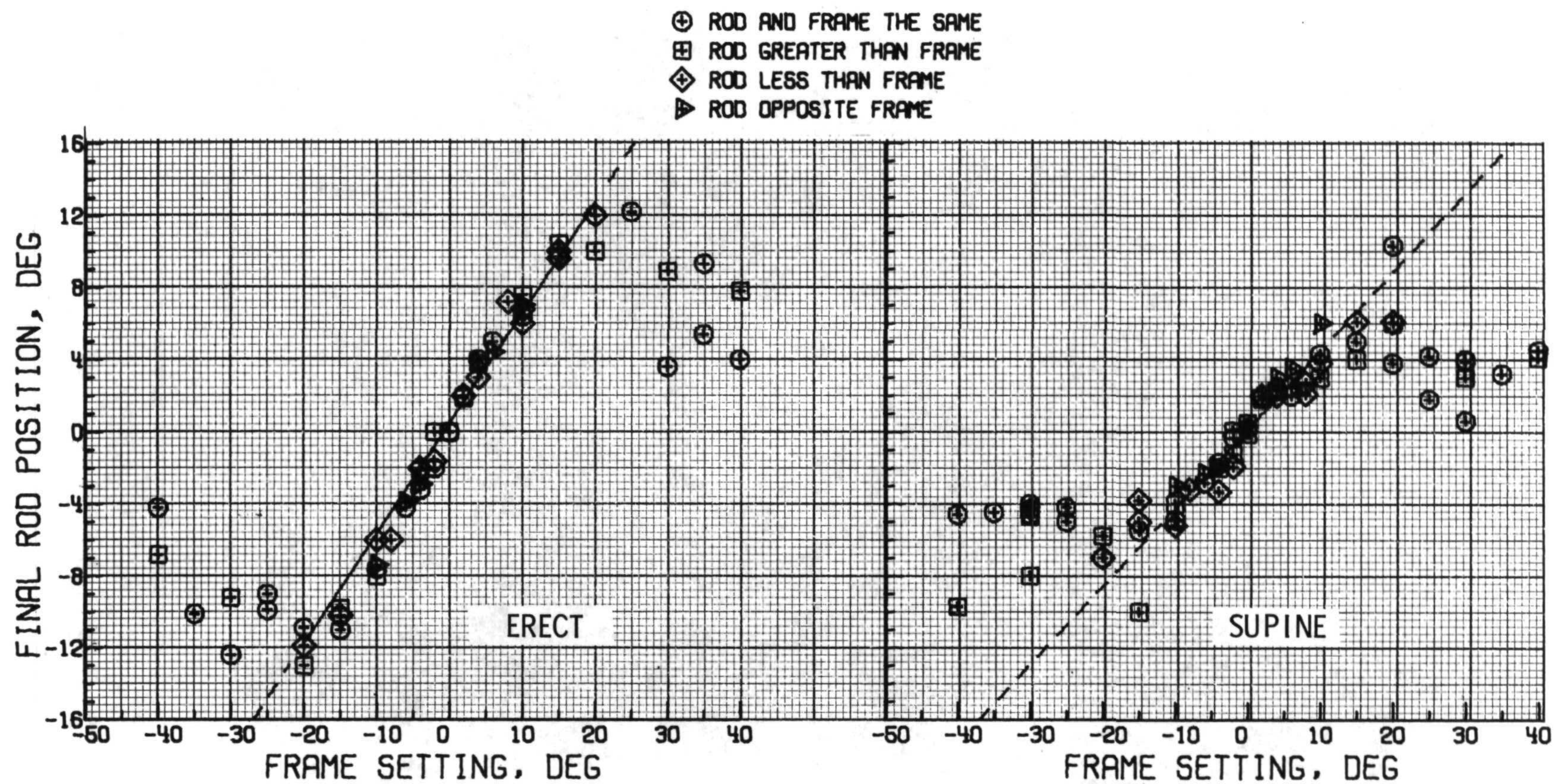


Figure 8.- Representative example of the response data in the erect and supine positions. (Data for subject 3.)

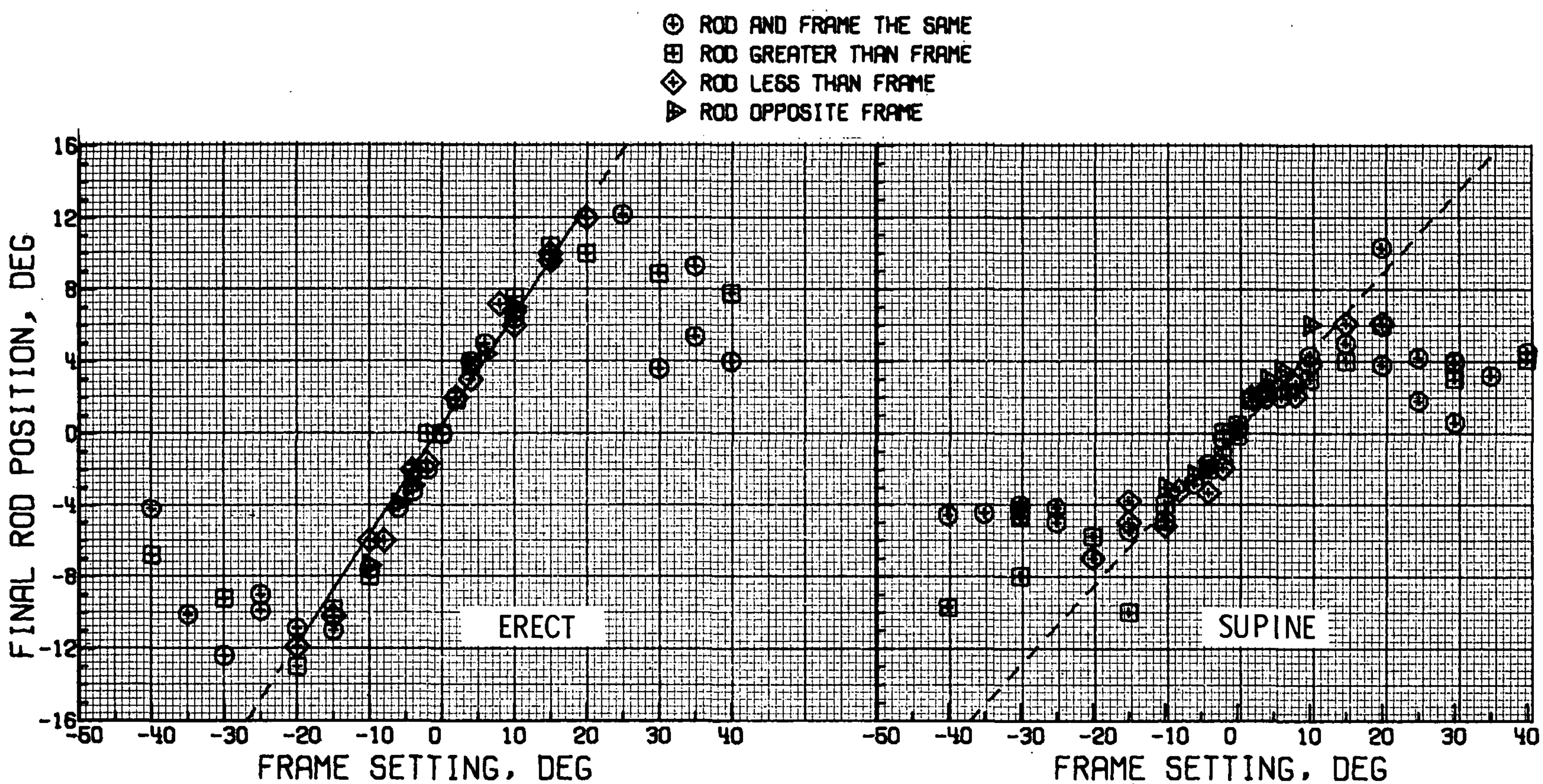


Figure 8.- Representative example of the response data in the erect and supine positions. (Data for subject 3.)

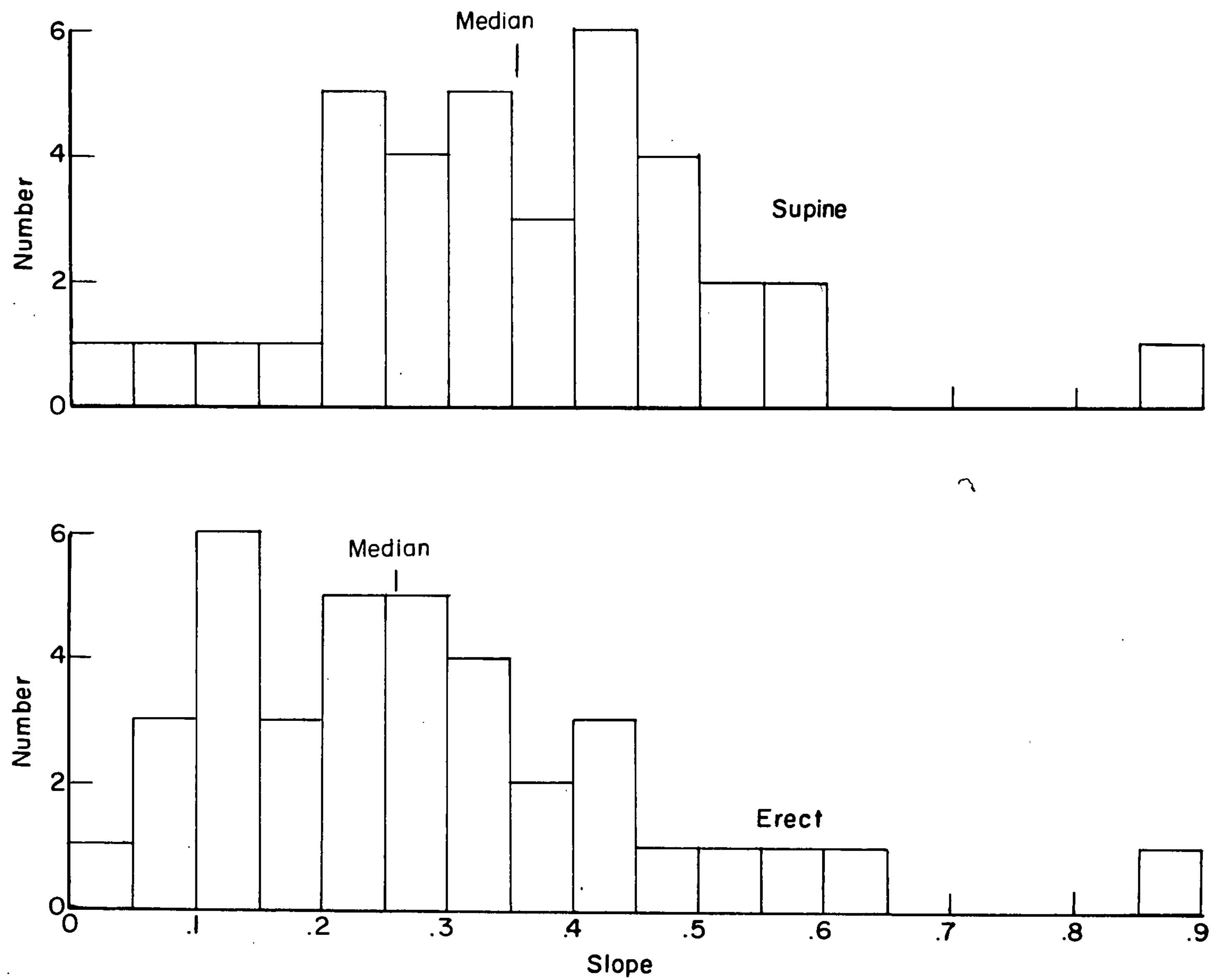


Figure 9.- Histograms of the slopes for all subjects. The numbers indicate the subjects that fell between the limits (i.e., 0 to 0.05, >0.05 to 0.10, etc.).

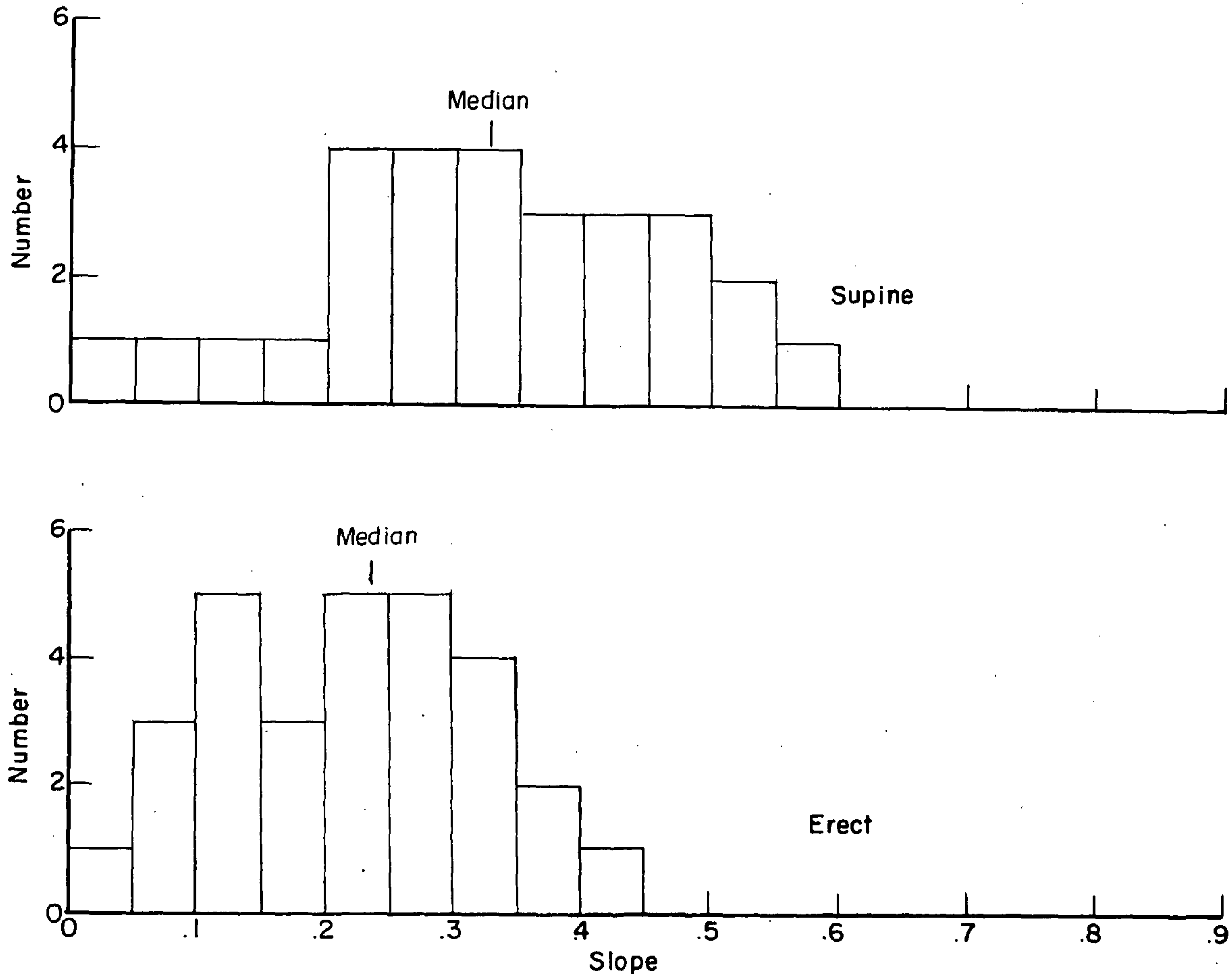


Figure 10.- Histograms of the slopes for the male subjects. The numbers indicate the subjects that fell between the limits (i.e., 0 to 0.05, >0.05 to 0.10, etc.).

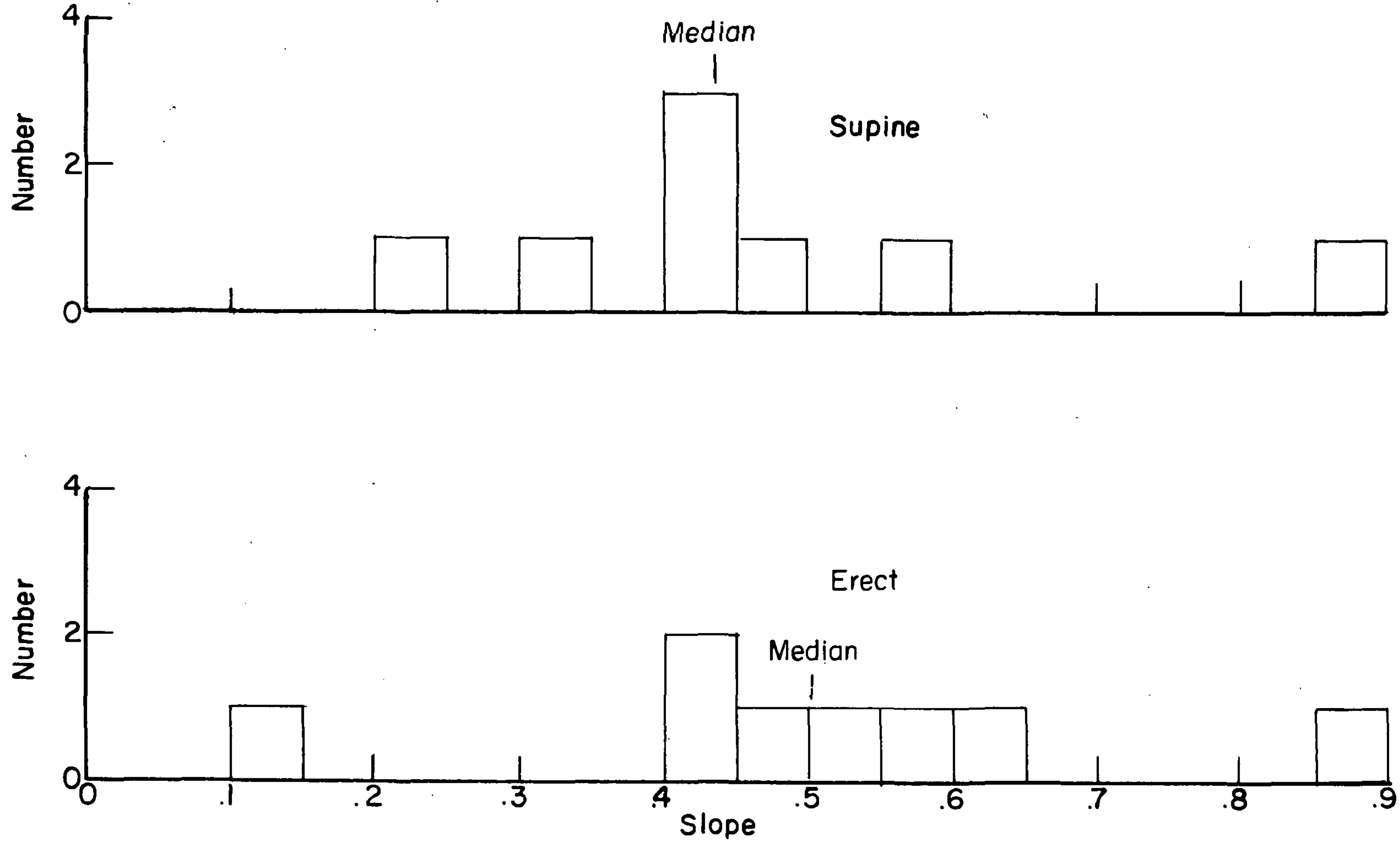


Figure 11.- Histograms of the slopes for the female subjects. The numbers indicate the subjects that fell between the limits (i.e., 0 to 0.05, >0.05 to 0.10, etc.).

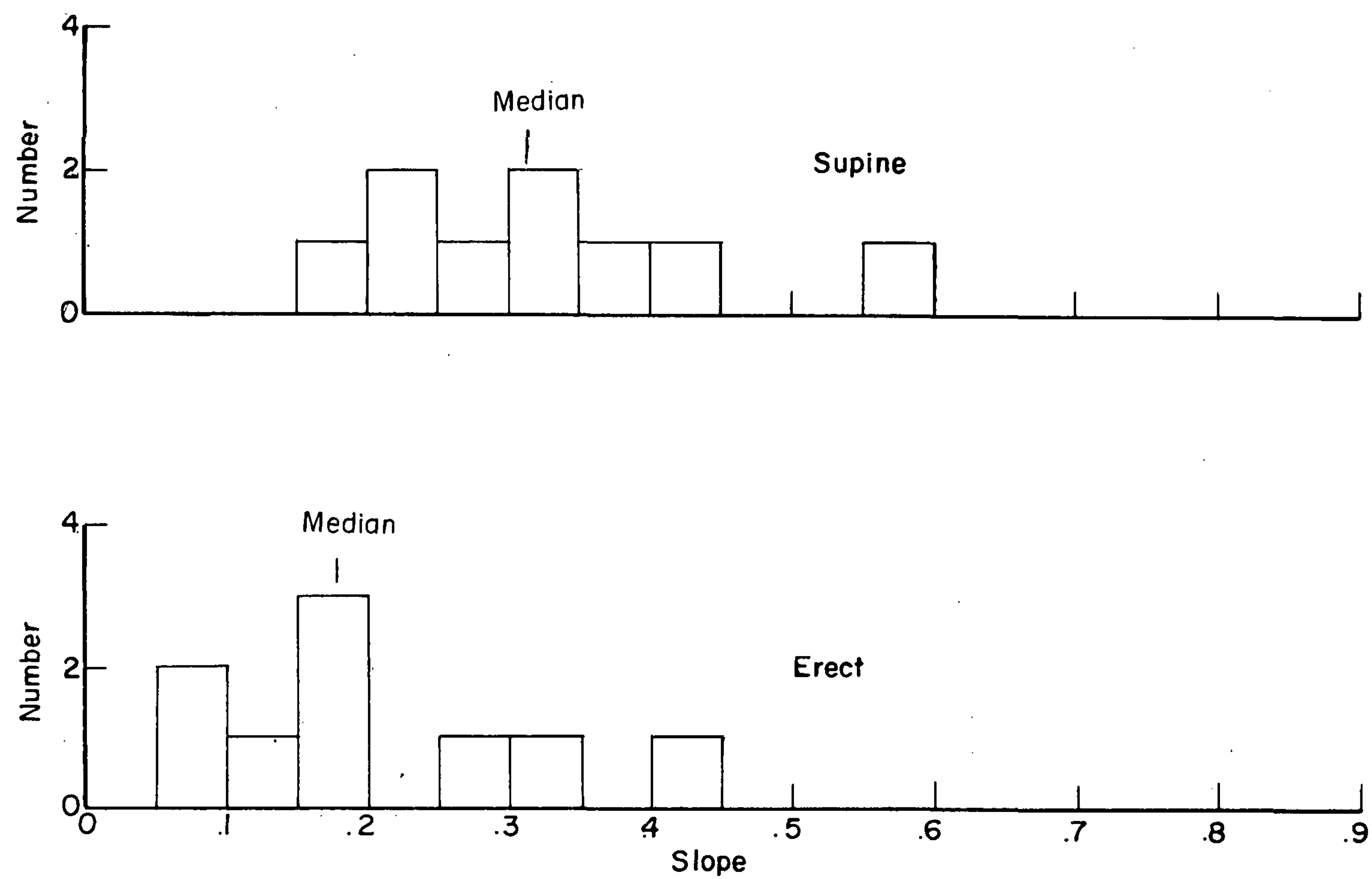


Figure 12.- Histograms of the slopes for the pilots. The numbers indicate the subjects that fell between the limits (i.e., 0 to 0.05, >0.05 to 0.10, etc.).

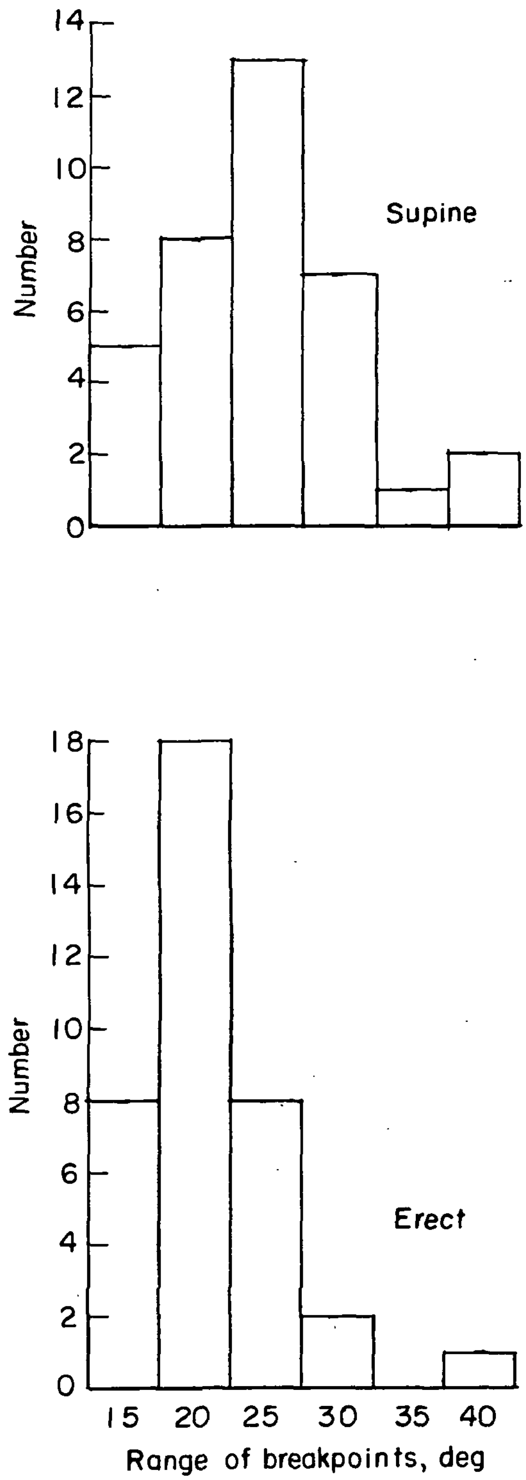


Figure 13.- Histograms of the breakpoints for all subjects. The numbers indicate the subjects that fell within a 5° spread (15 = 12.5 to 17.5; 20 = >17.5 to 22.5; etc.).

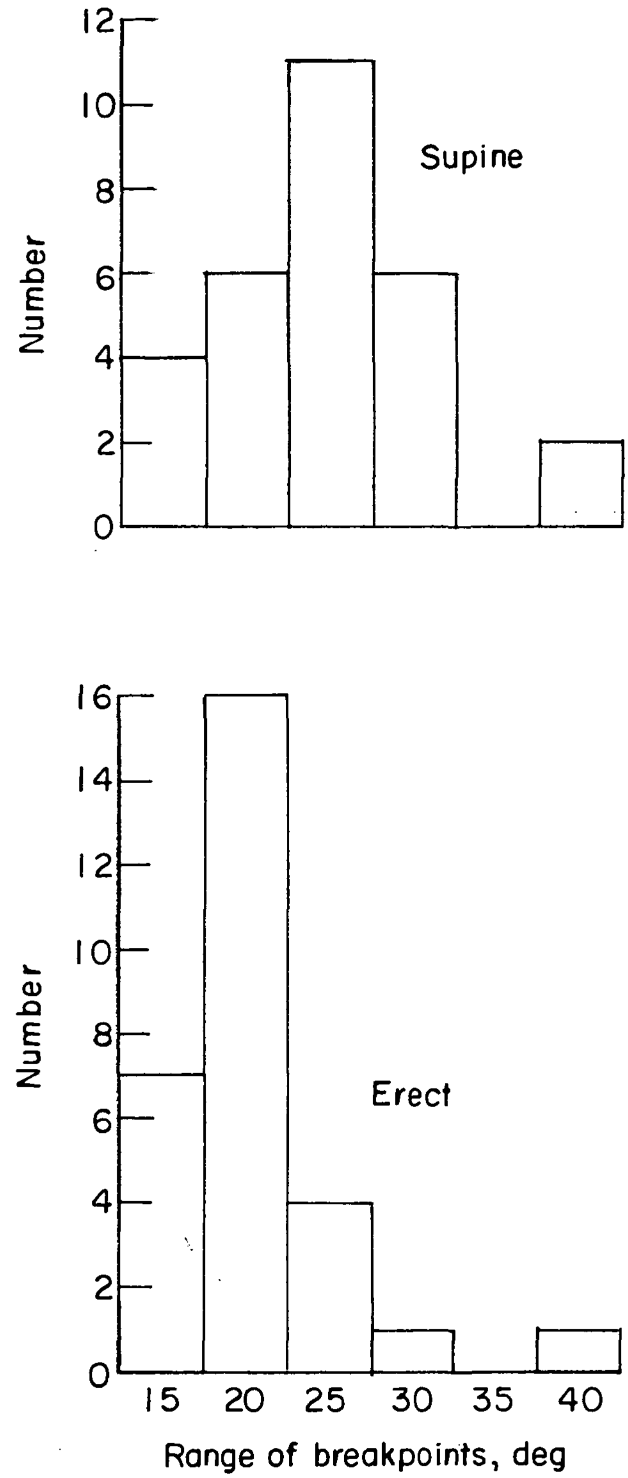


Figure 14.- Histograms of the breakpoints for the male subjects.

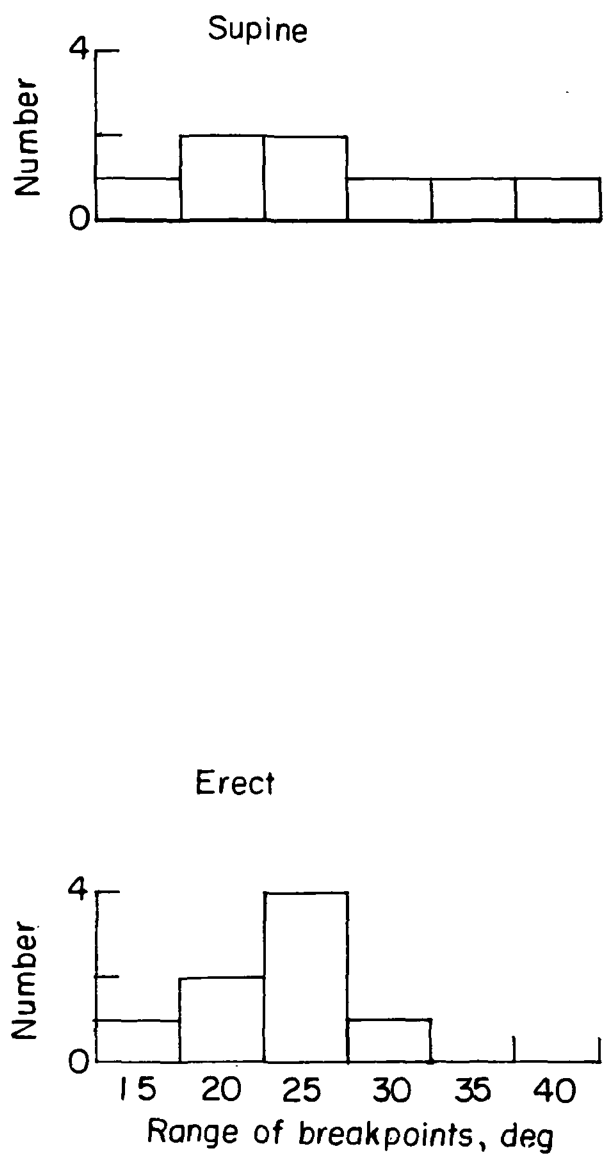


Figure 15.- Histograms of the breakpoints for the female subjects.

Figure 16.- Histograms of the breakpoints for the pilots.

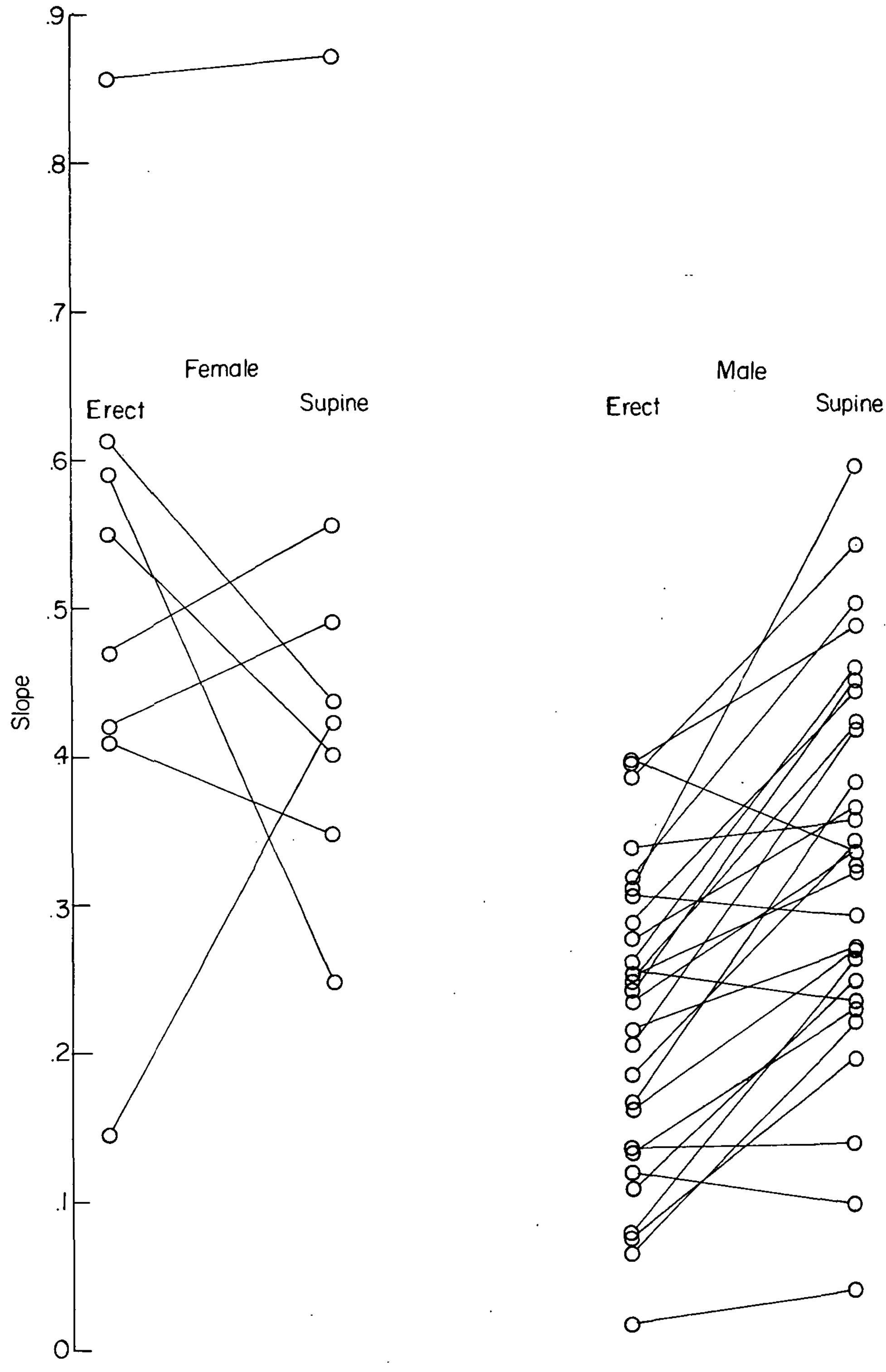


Figure 17.- Slopes for the erect and supine positions. The lines indicate the change in slope from erect to supine.

APPENDIX A

BASIC ROD AND FRAME DATA FOR TEST SUBJECTS

The basic data for the rod and frame tests are presented for the 37 subjects in figures A1 to A37. The results for the erect and supine positions are presented side by side in order to facilitate direct comparison. A listing of the sex, age, and basic occupation of the subjects is presented in table AI. (No extensive analysis of the data is made; however, some pertinent comments on the data are included.)

Inspection of the data reveals the wide variation of the subject's estimation of the vertical under the influence of an individual frame setting. This wide variation appears to be characteristic of all the subjects, although much more of some subjects than of other subjects. Also, among the data for some subjects, there is an occasional data point that is quite far removed from the rest of the data points (see, e.g., subject 22 supine, the point at rod $+8^{\circ}$, frame -30°, or subject 18 erect, the point at rod $+4^{\circ}$, frame -30°). These points would fit the data better if the opposite sign for either the rod or frame reading was used. There are essentially three ways for these odd points to occur:

(1) The point is actually correct and is indicative of the spread of the response.

(2) The experimenter inadvertently set the rod and frame incorrectly, that is, a plus setting when a minus setting was meant.

(3) The experimenter read the instruments incorrectly.

Since, at this time, there is no way to determine whether either of the two types of error was committed, the points were assumed to be correct and were used in the data reduction for the best-fit straight line, standard deviation, and so forth.

APPENDIX A

TABLE AI. - PERSONAL DATA OF TEST SUBJECTS

Subject	Sex	Age	Basic occupation
1	Female	26	Mathematician
2		29	Mathematician
3		25	Secretary
4		25	Secretary
5		22	Secretary
6		47	Math Aid
7		49	Math Aid
8		52	Math Aid
9	Male	22	Engineer
10		27	Engineer
11		21	Technician
12		23	Engineer
13		29	Mathematician
14		24	Engineer
15		33	Engineer
16		33	Mathematician
17		33	Engineer
18		33	Physicist
19		36	Test pilot
20		38	Test pilot
21		36	Test pilot
22		31	Test pilot
23		41	Physicist
24		44	Engineer
25		49	Technician
26		44	Engineer
27		42	Test pilot
28		43	Test pilot
29		50	Engineer
30		50	Math Physicist
31		54	Technician
32		50	Engineer
33		50	Technician
34		52	Engineer
35		50	Test pilot
36		50	Test pilot
37		52	Pilot

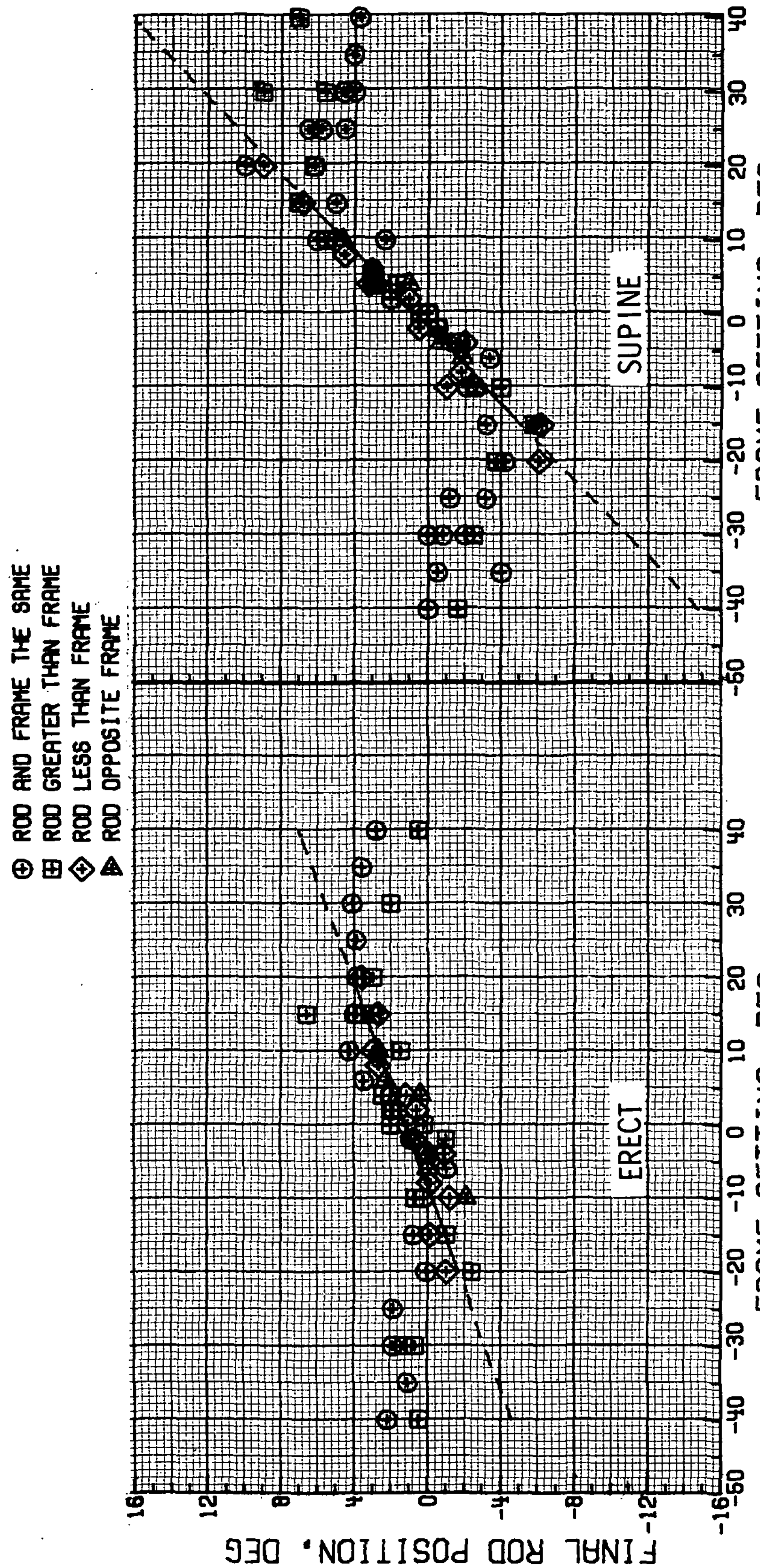


Figure A1.- Response data for subject 1.

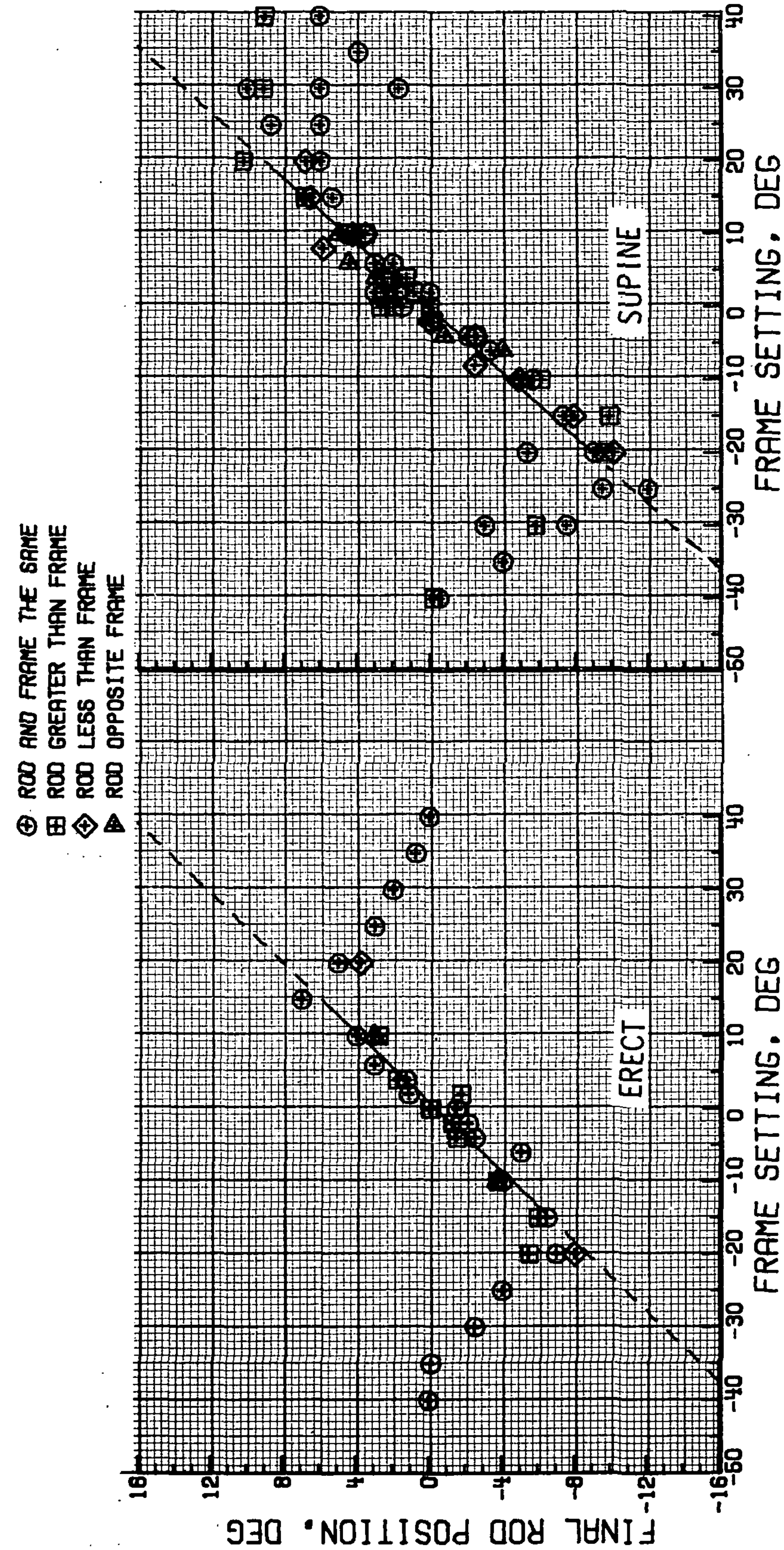


Figure A2.- Response data for subject 2.

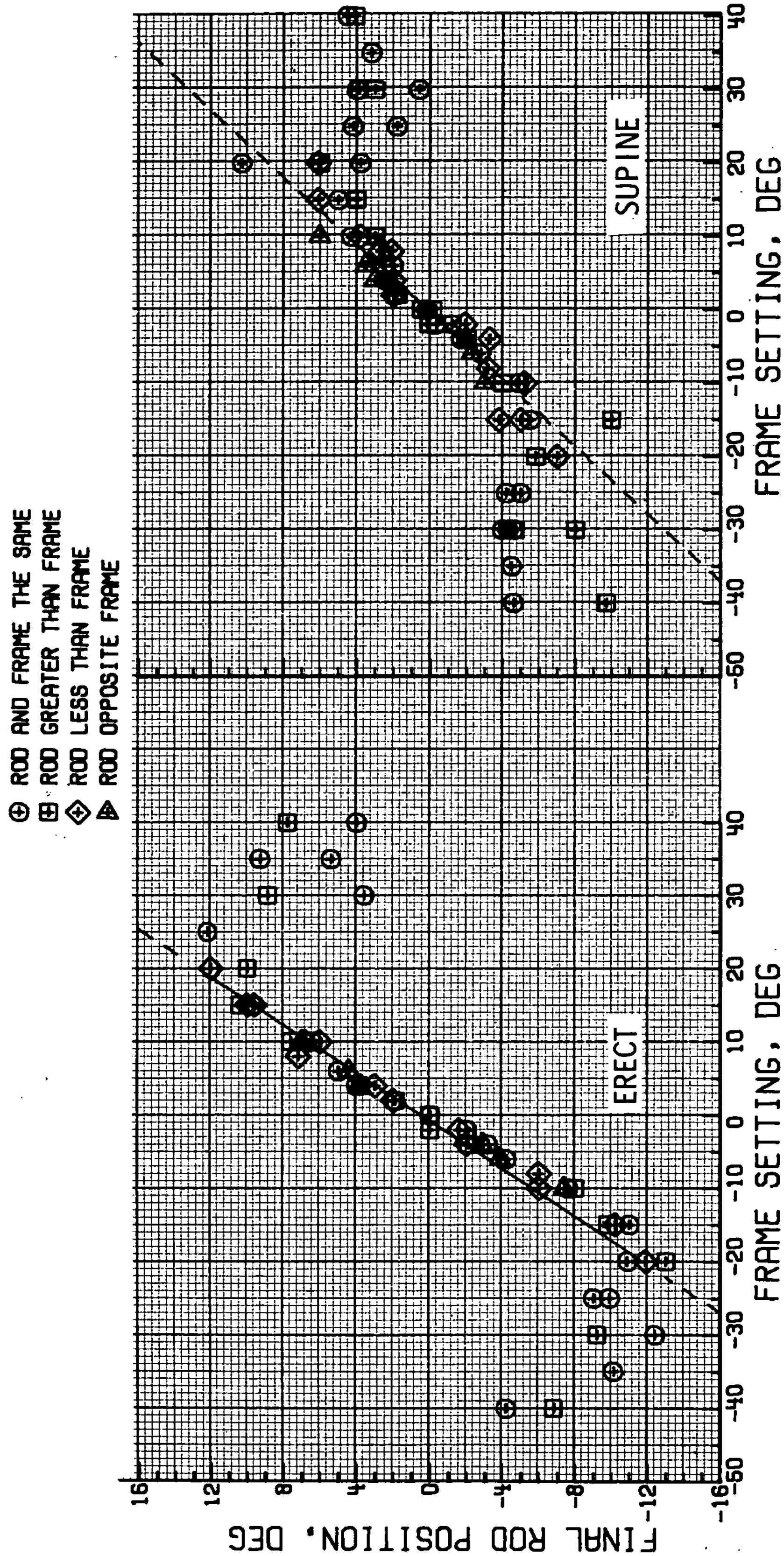


Figure A3.- Response data for subject 3.

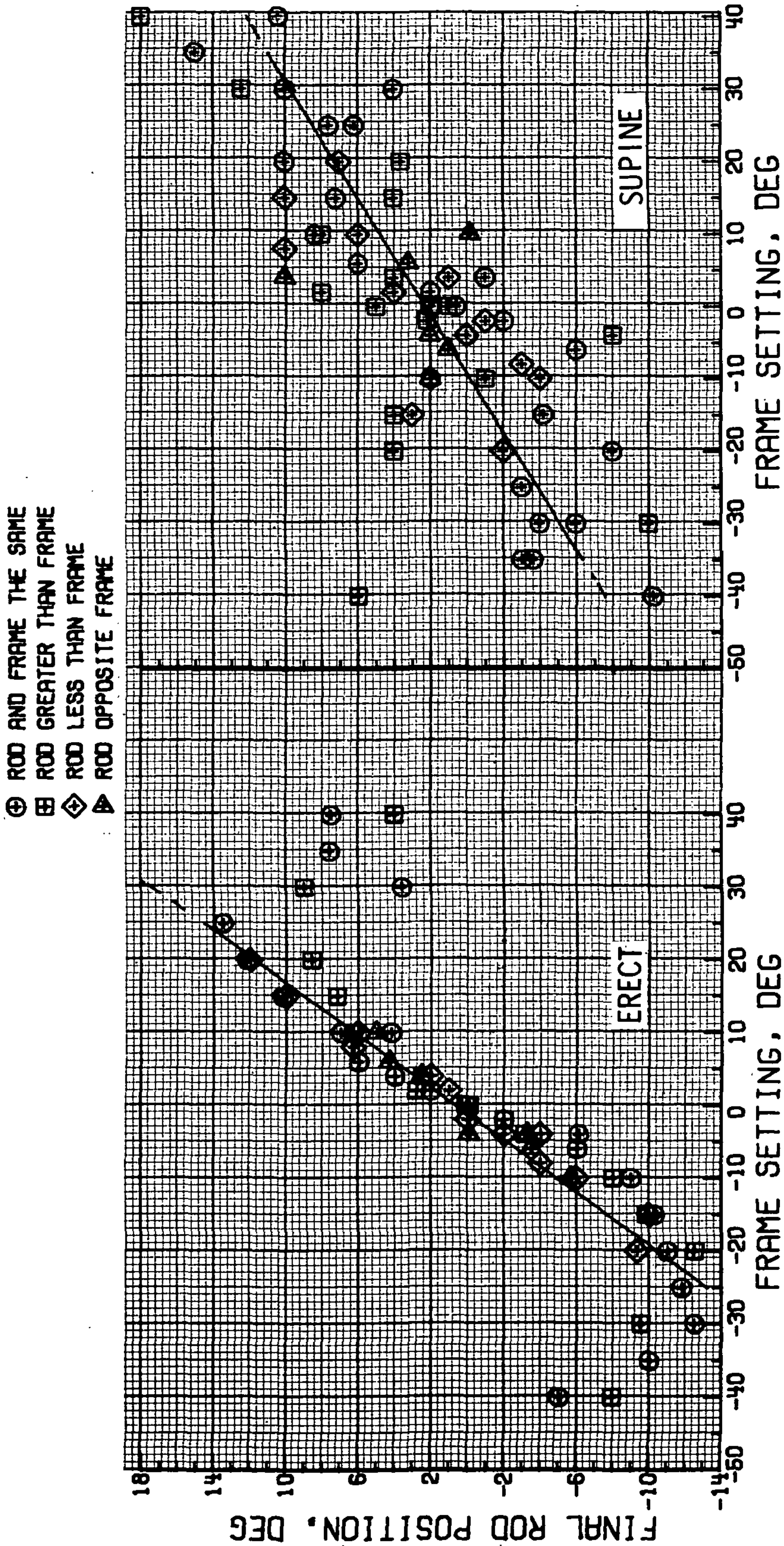


Figure A4.- Response data for subject 4.

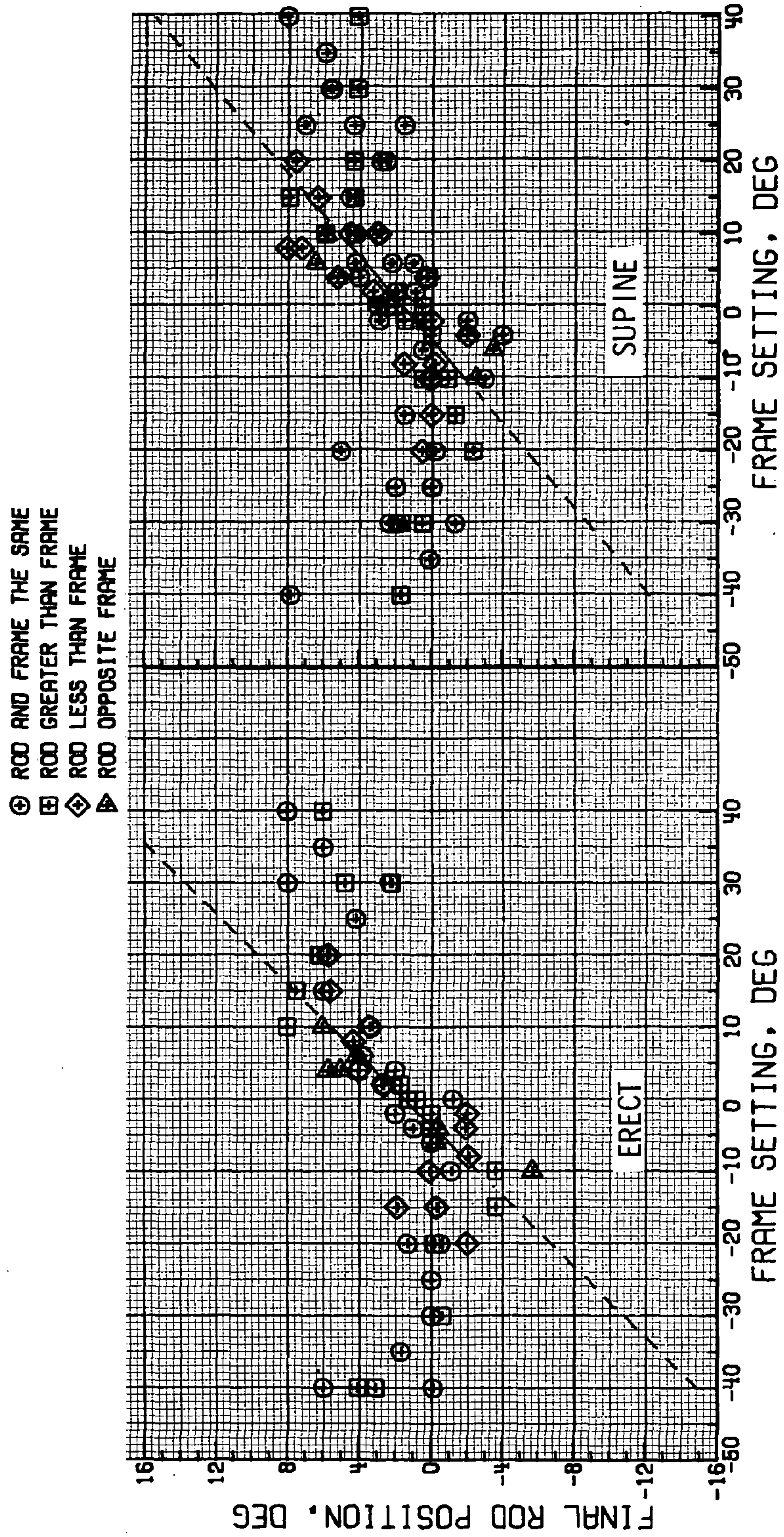


Figure A5.- Response data for subject 5.

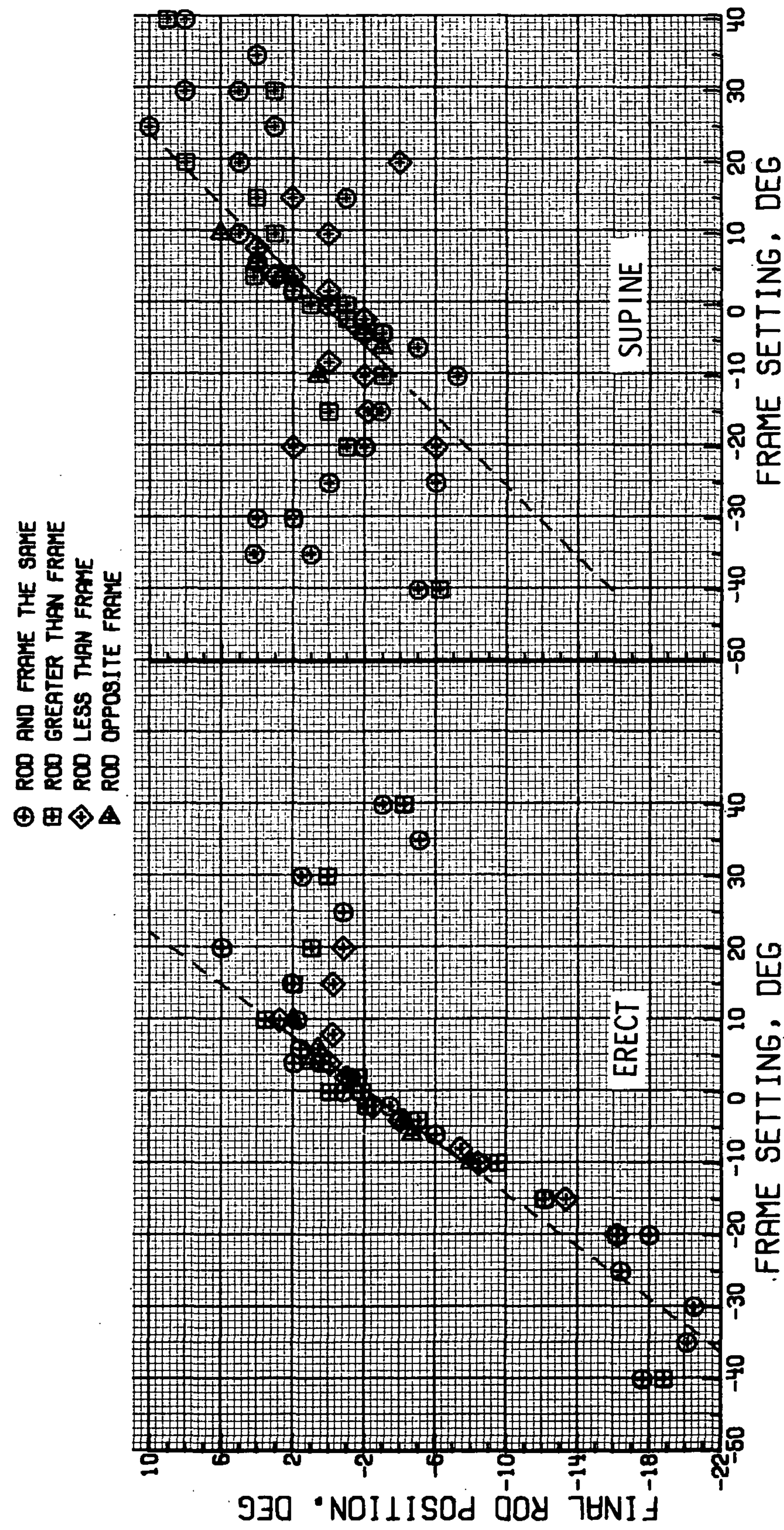


Figure A6.- Response data for subject 6.

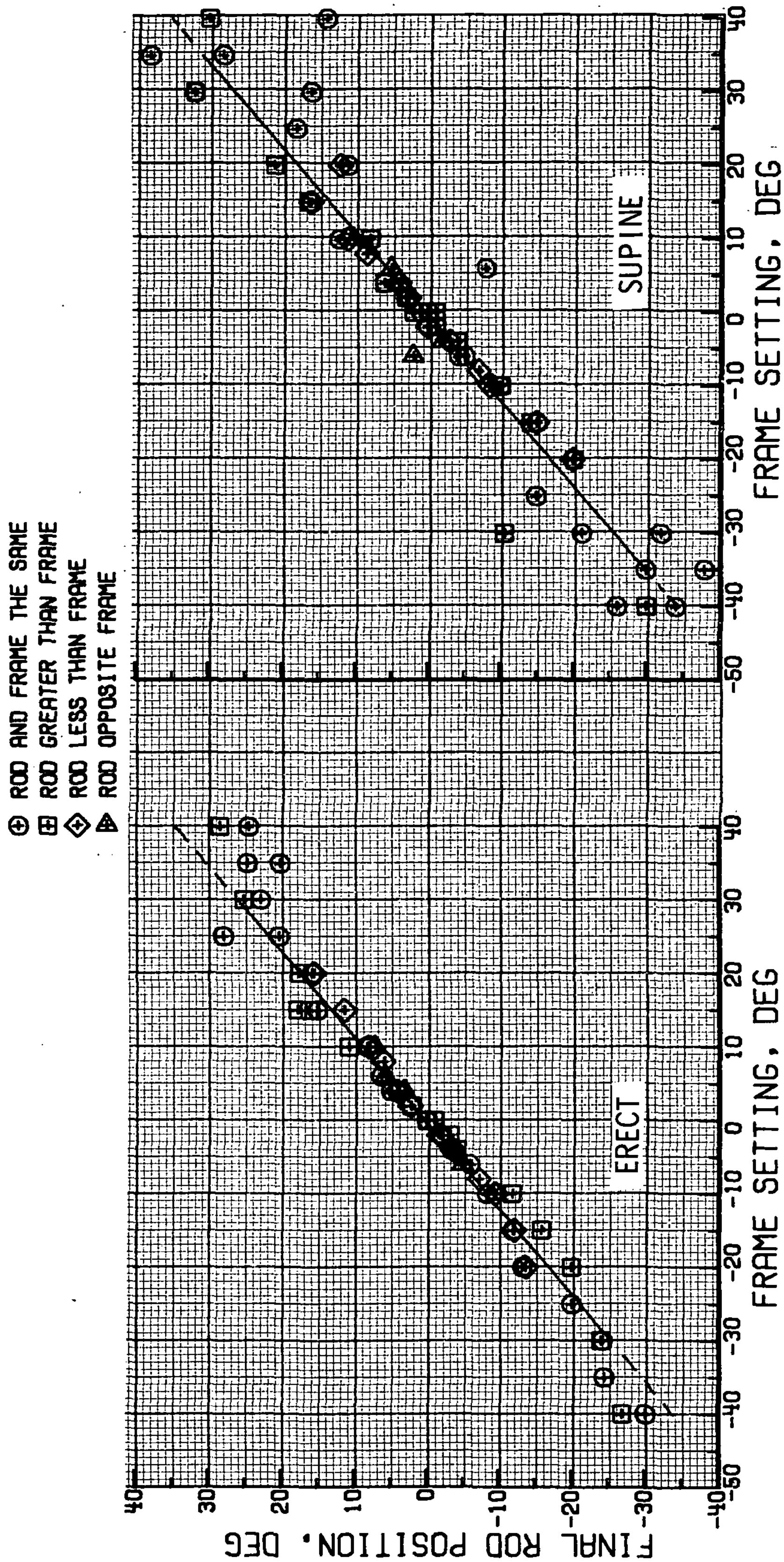


Figure A7.- Response data for subject 7.

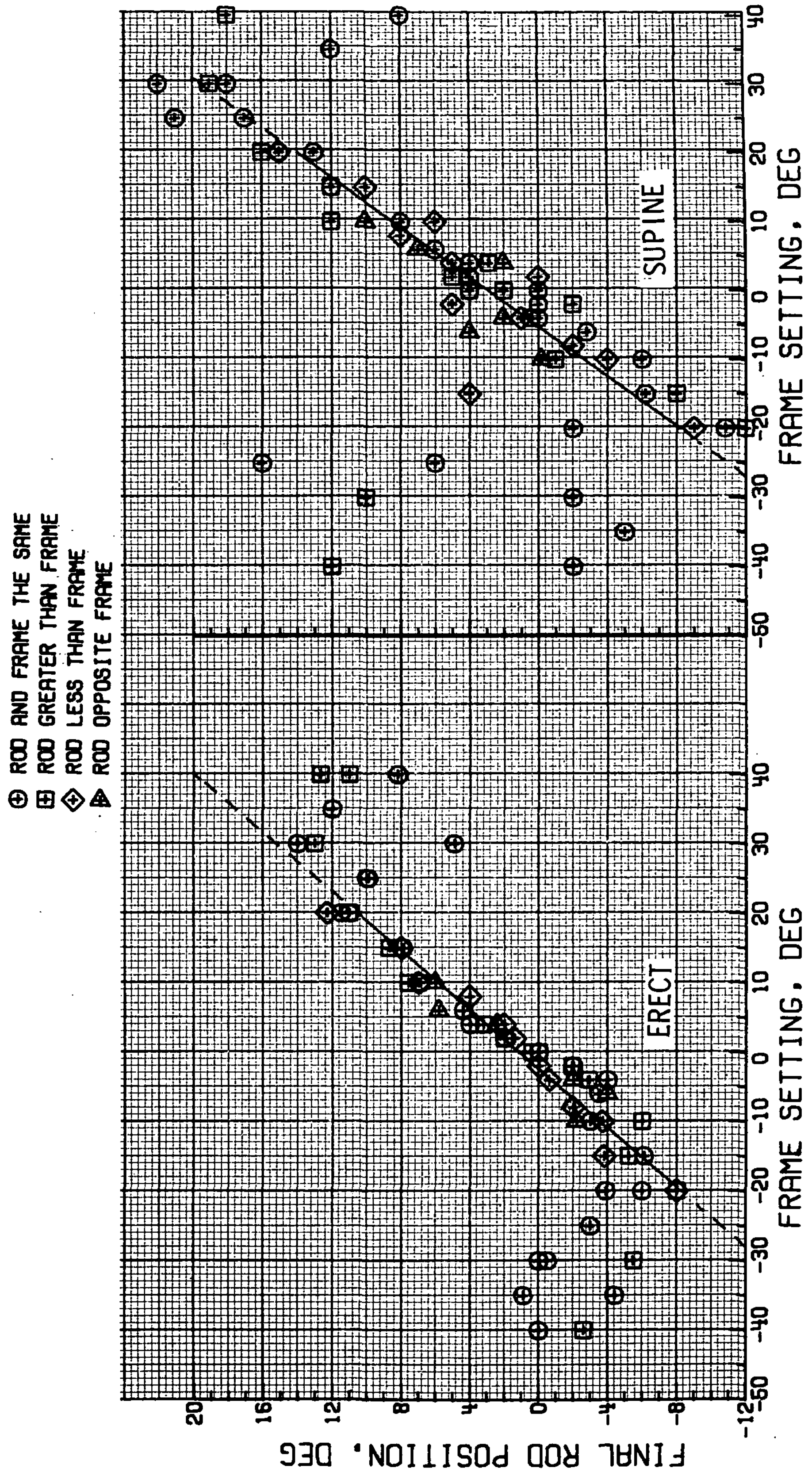


Figure A8.- Response data for subject 8.

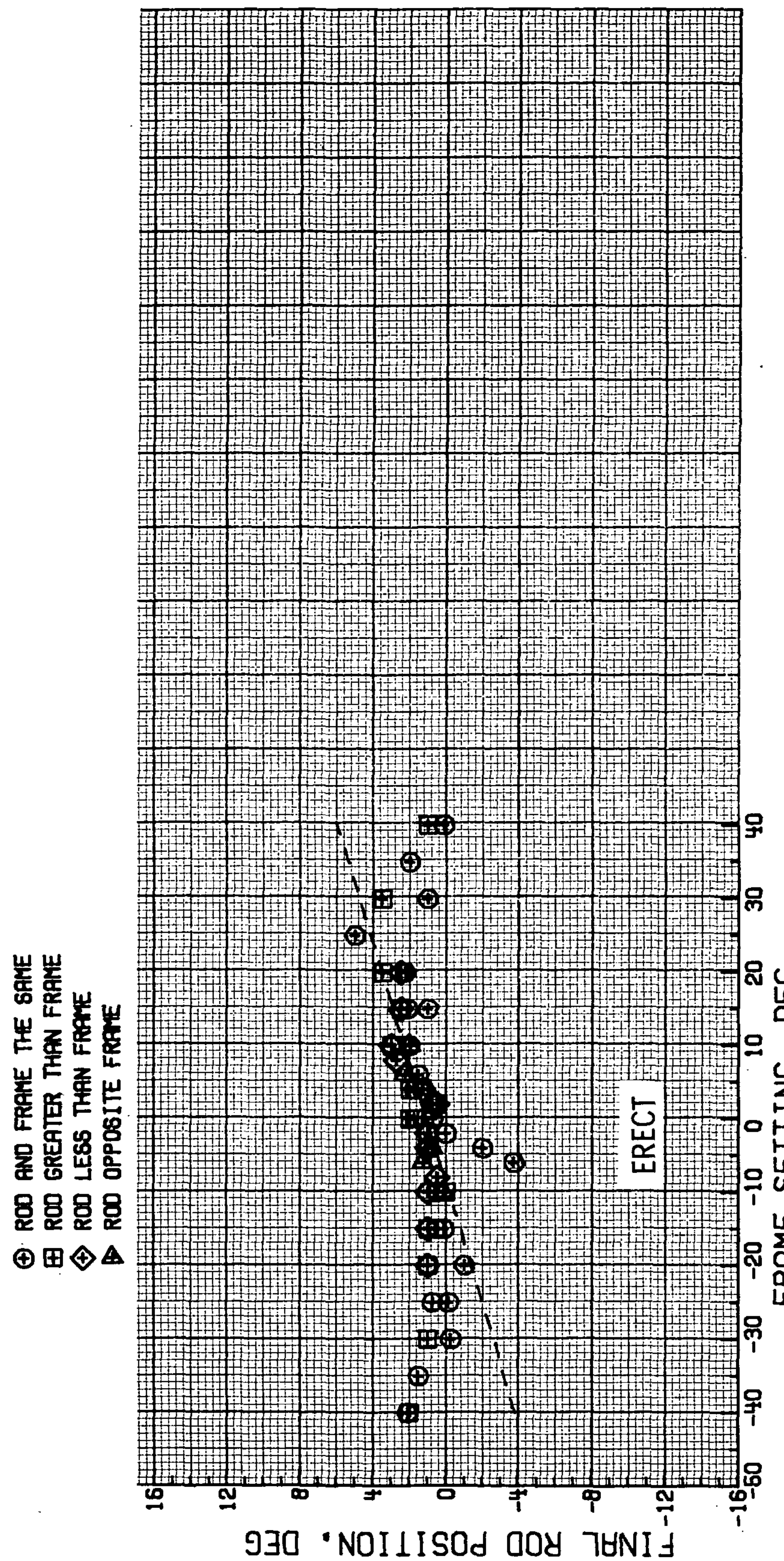


Figure A9.- Response data for subject 9.

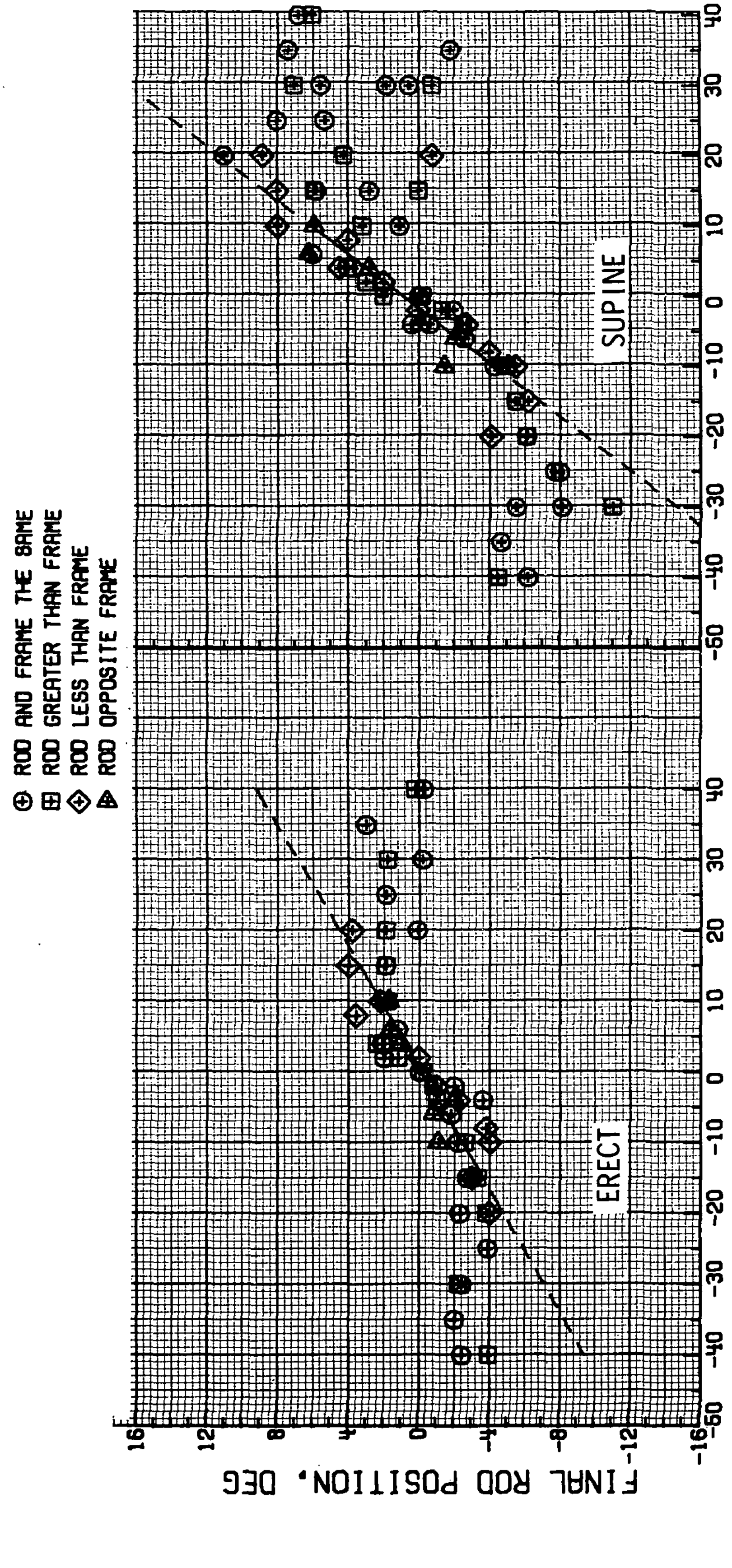


Figure A10.- Response data for subject 10.

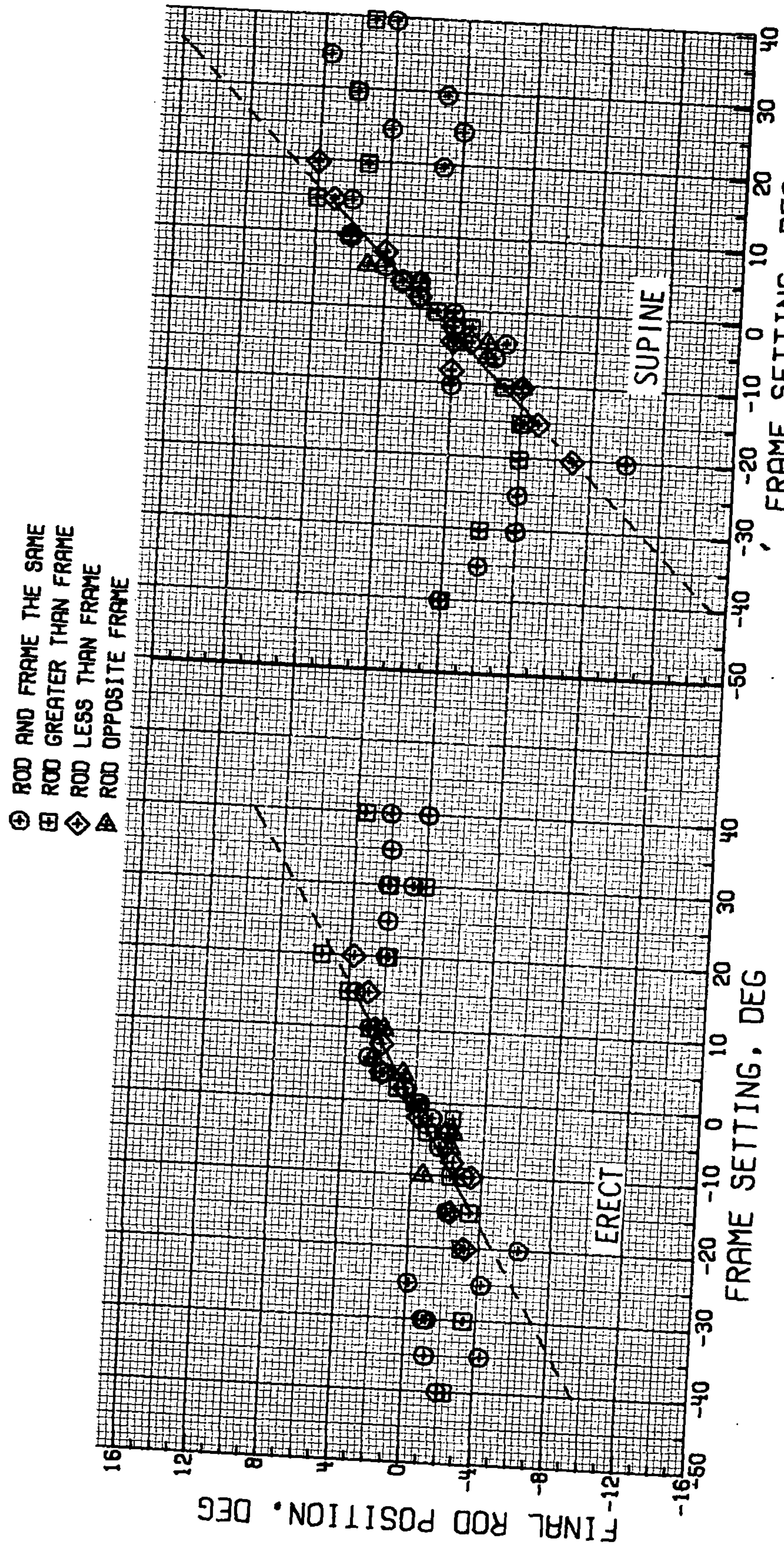


Figure A11.- Response data for subject 11.

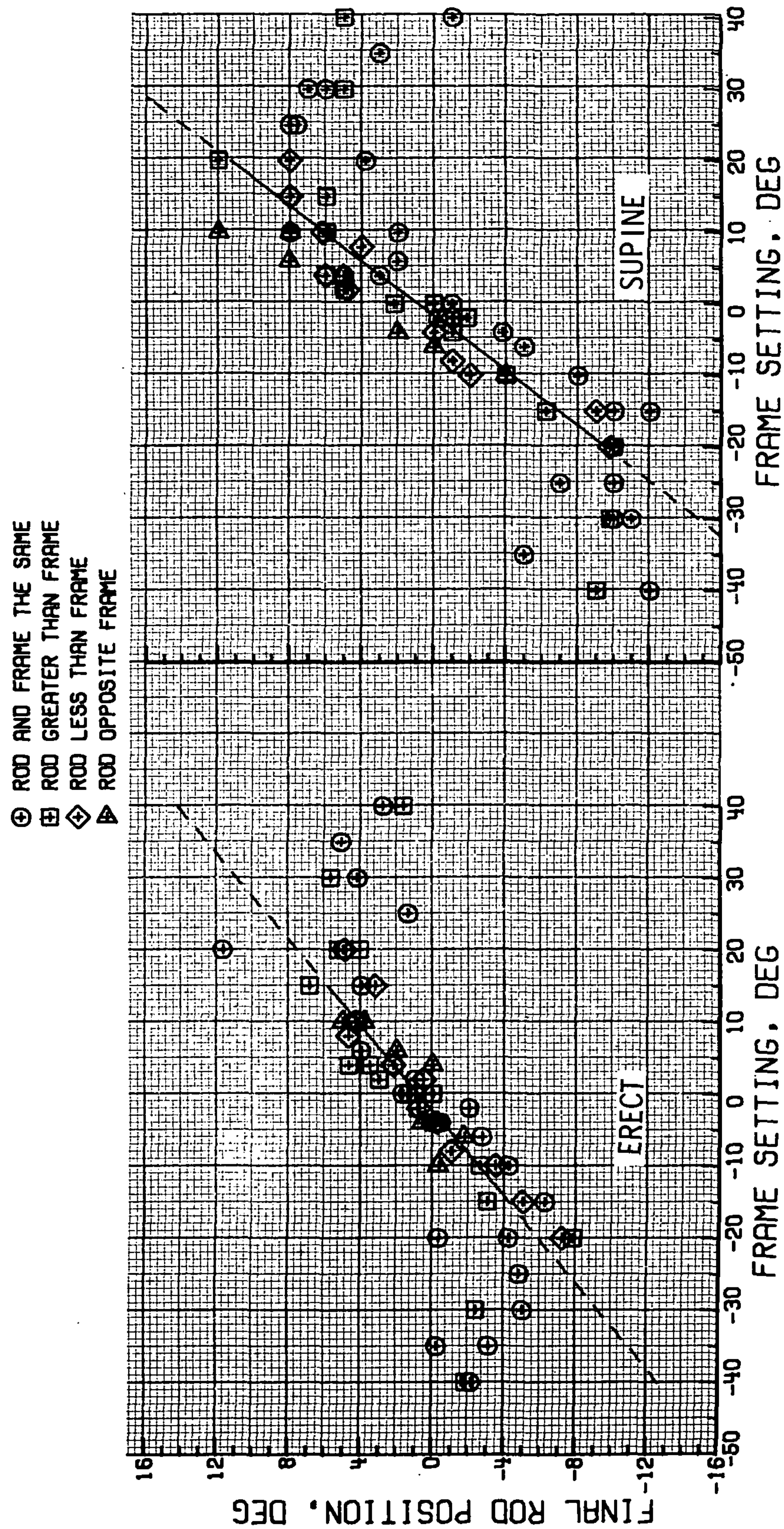


Figure A12.- Response data for subject 12.

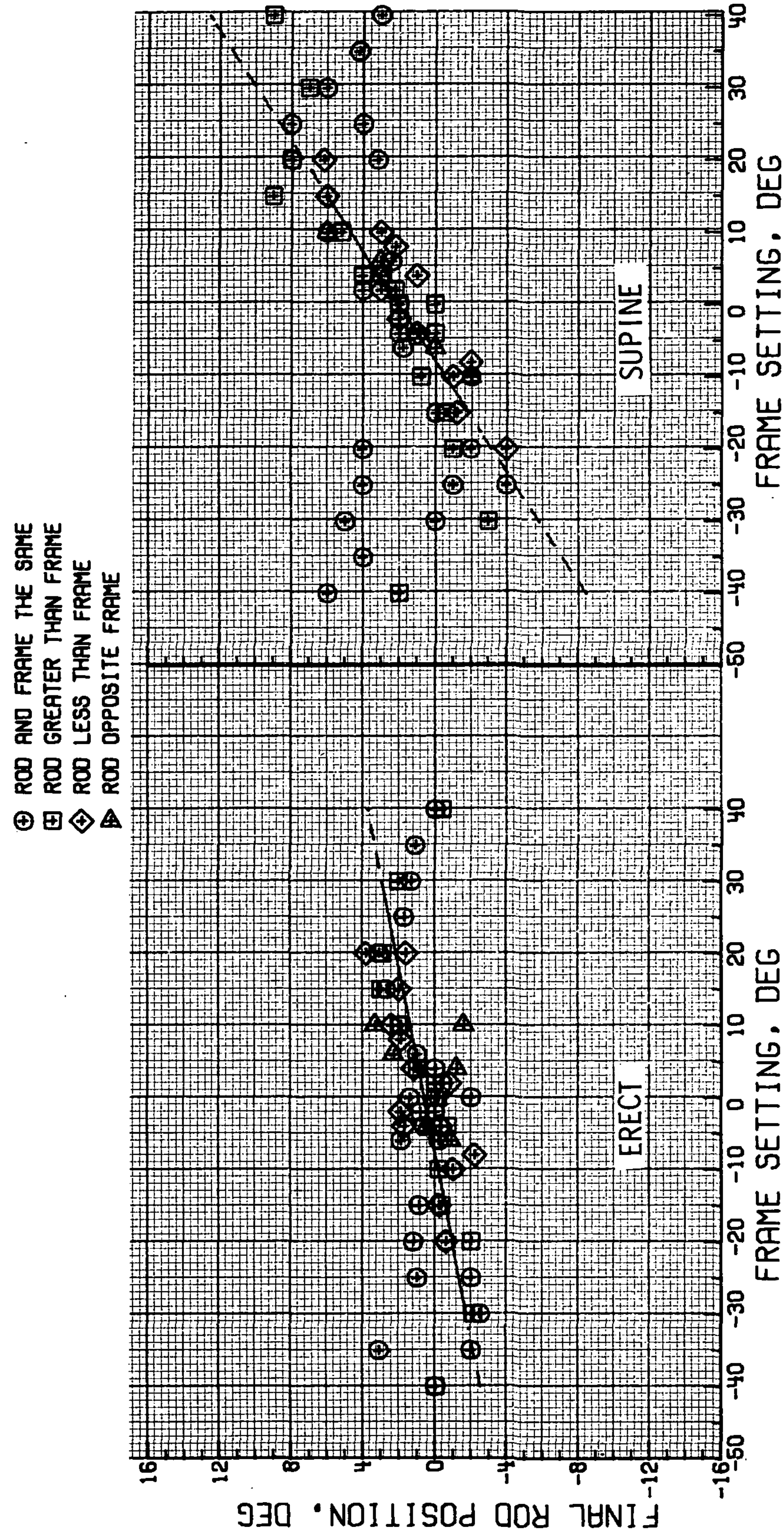


Figure A13.- Response data for subject 13.

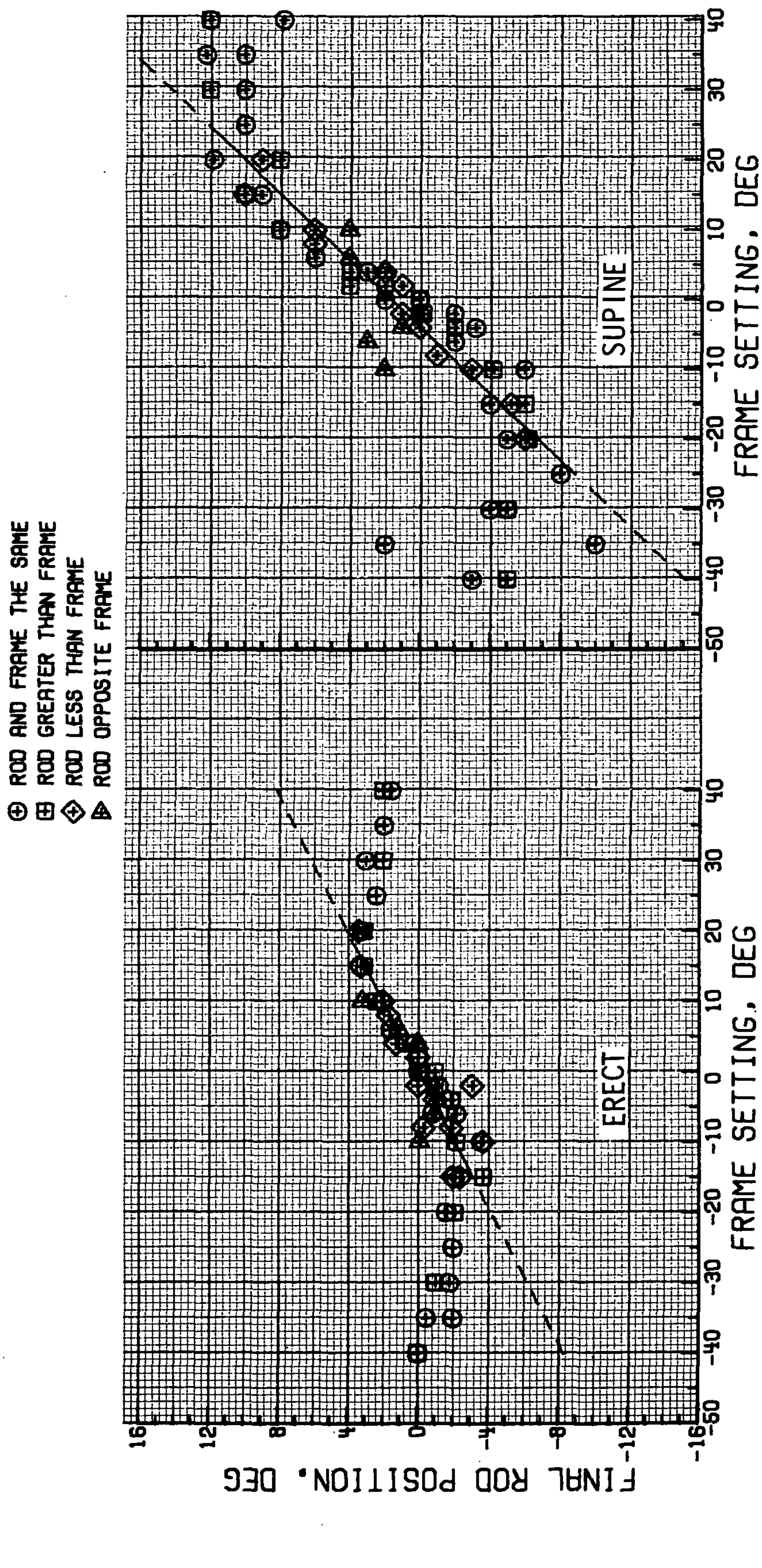


Figure A14.- Response data for subject 14.

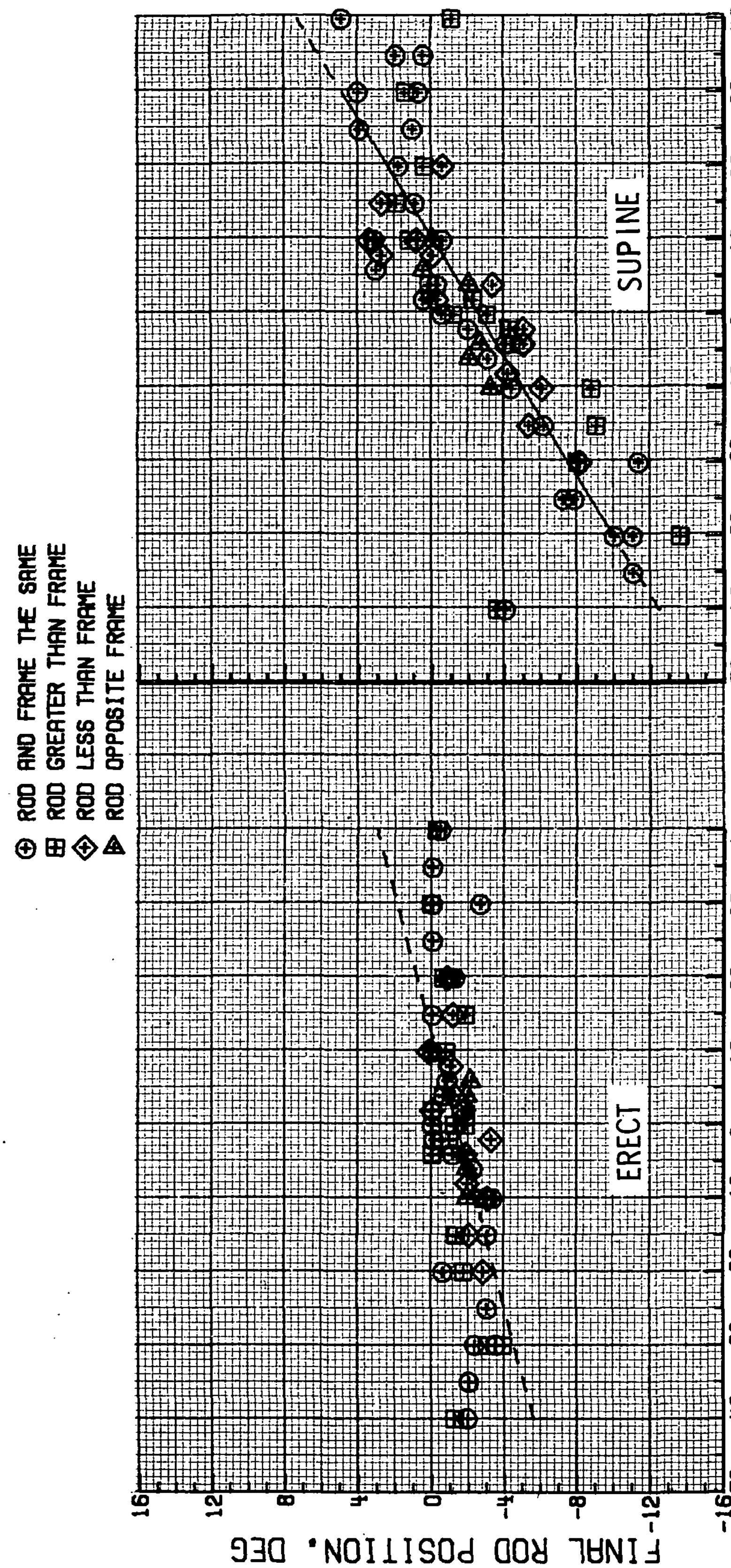


Figure A15.- Response data for subject 15.

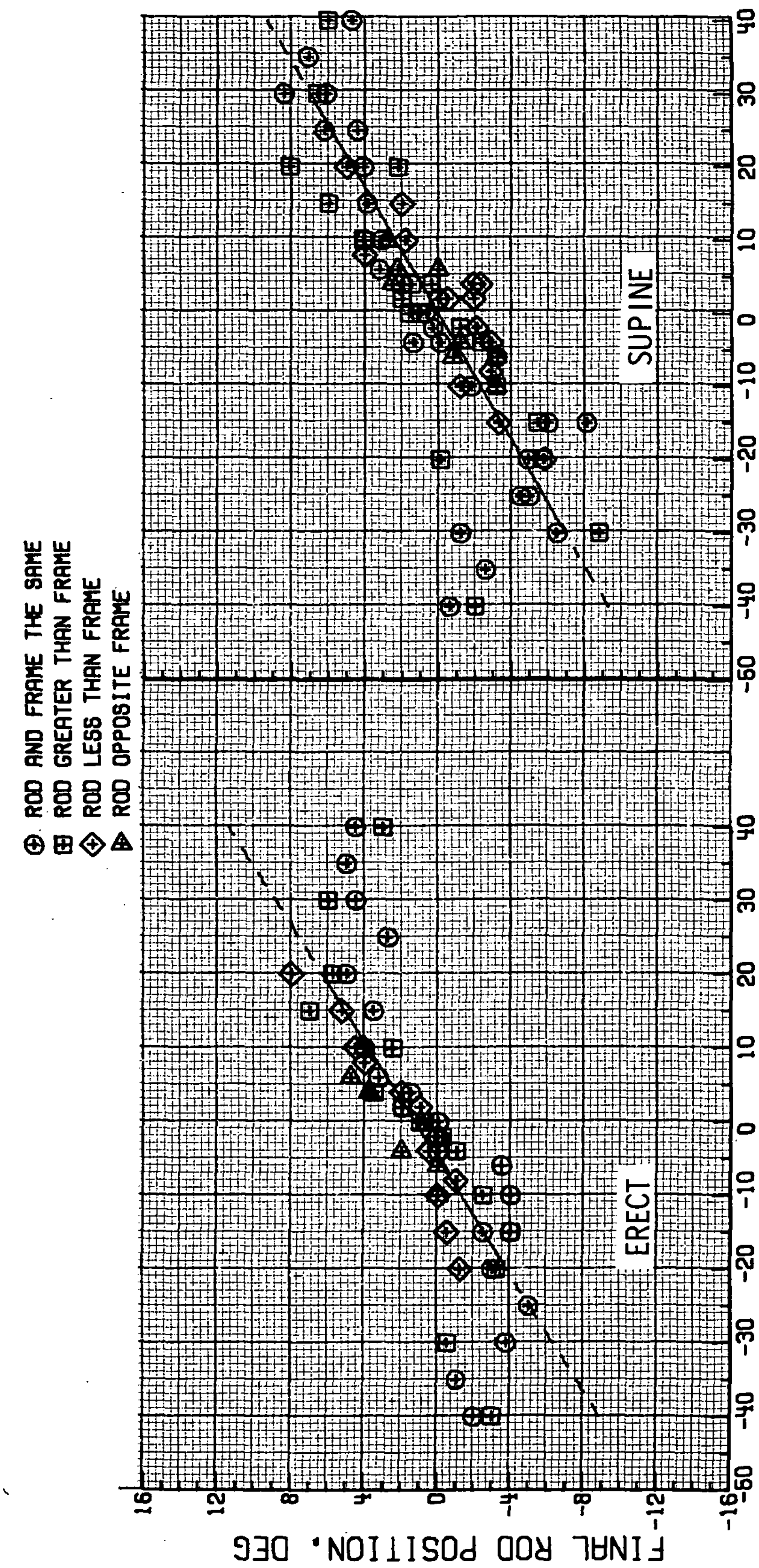


Figure A16.- Response data for subject 16.

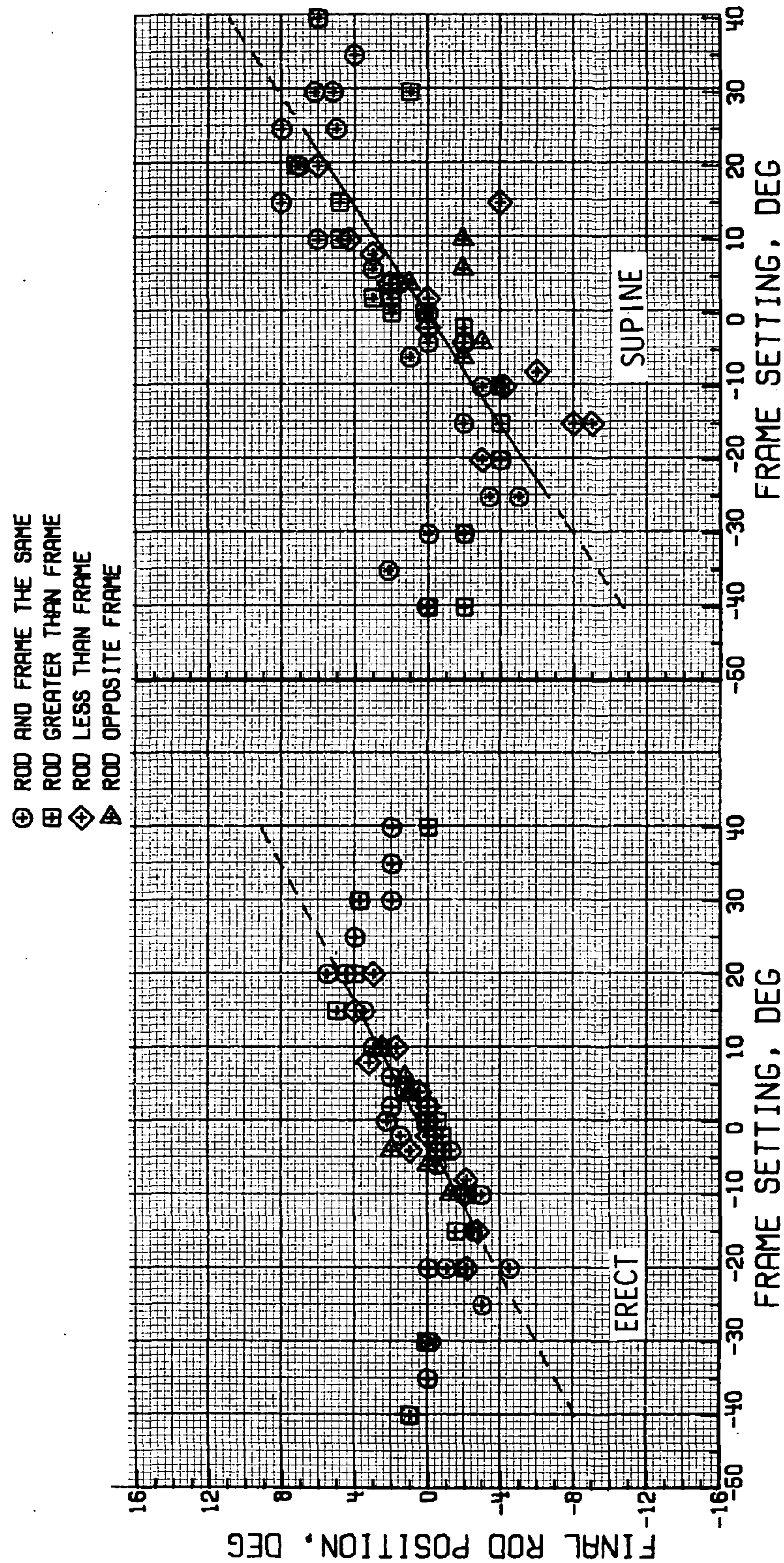


Figure A17.- Response data for subject 17.

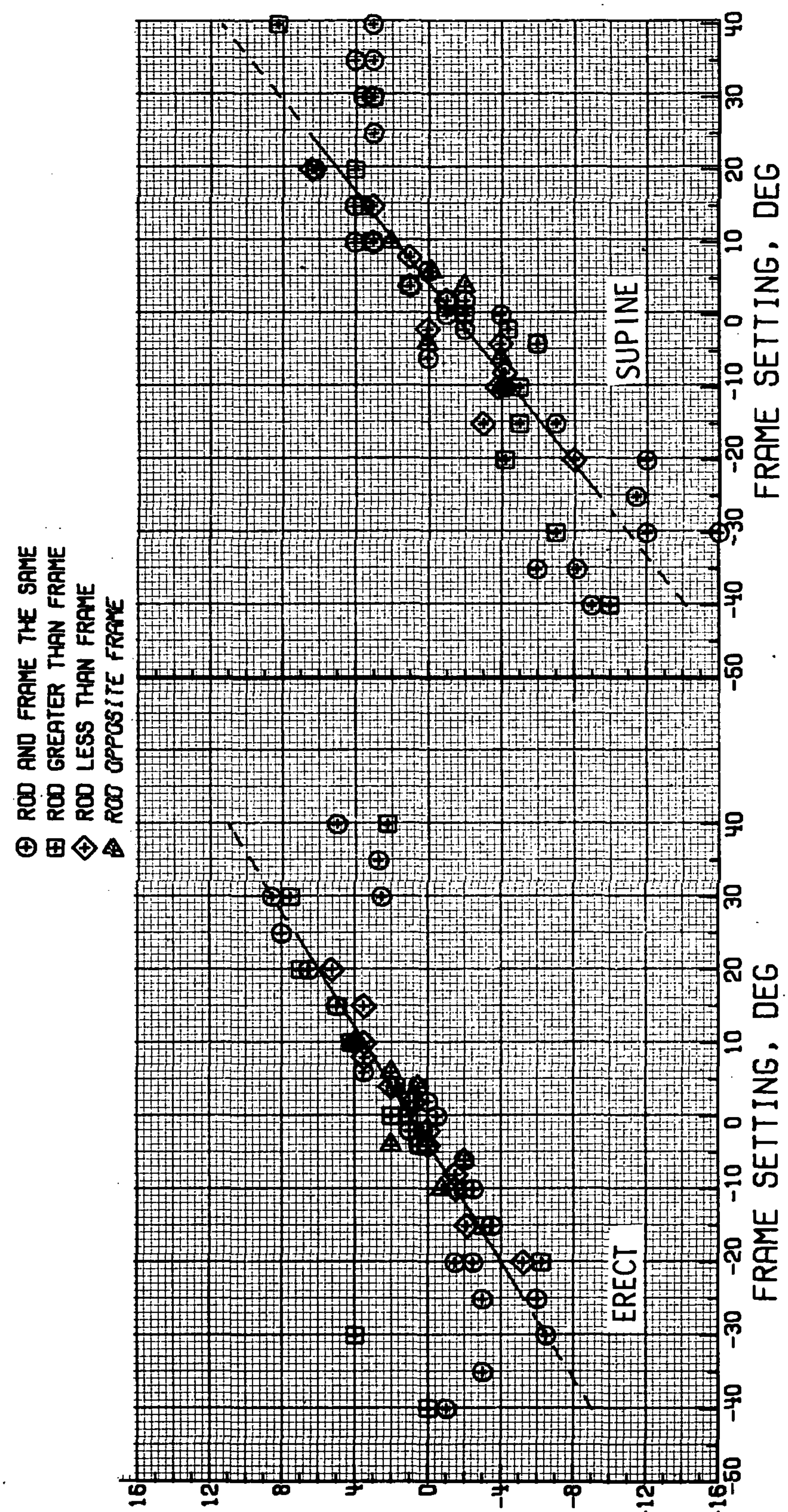


Figure A18.- Response data for subject 18.

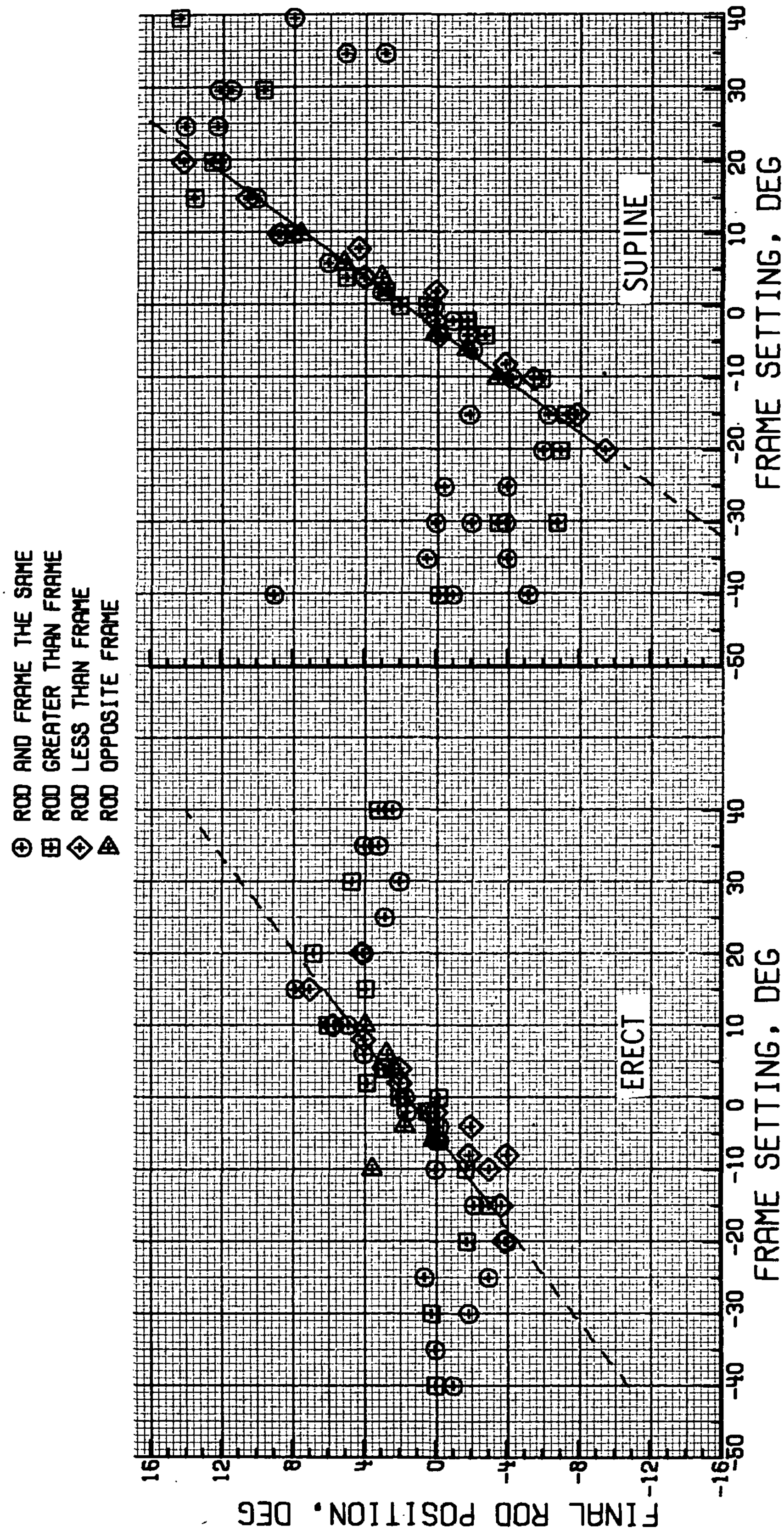


Figure A19.- Response data for subject 19.

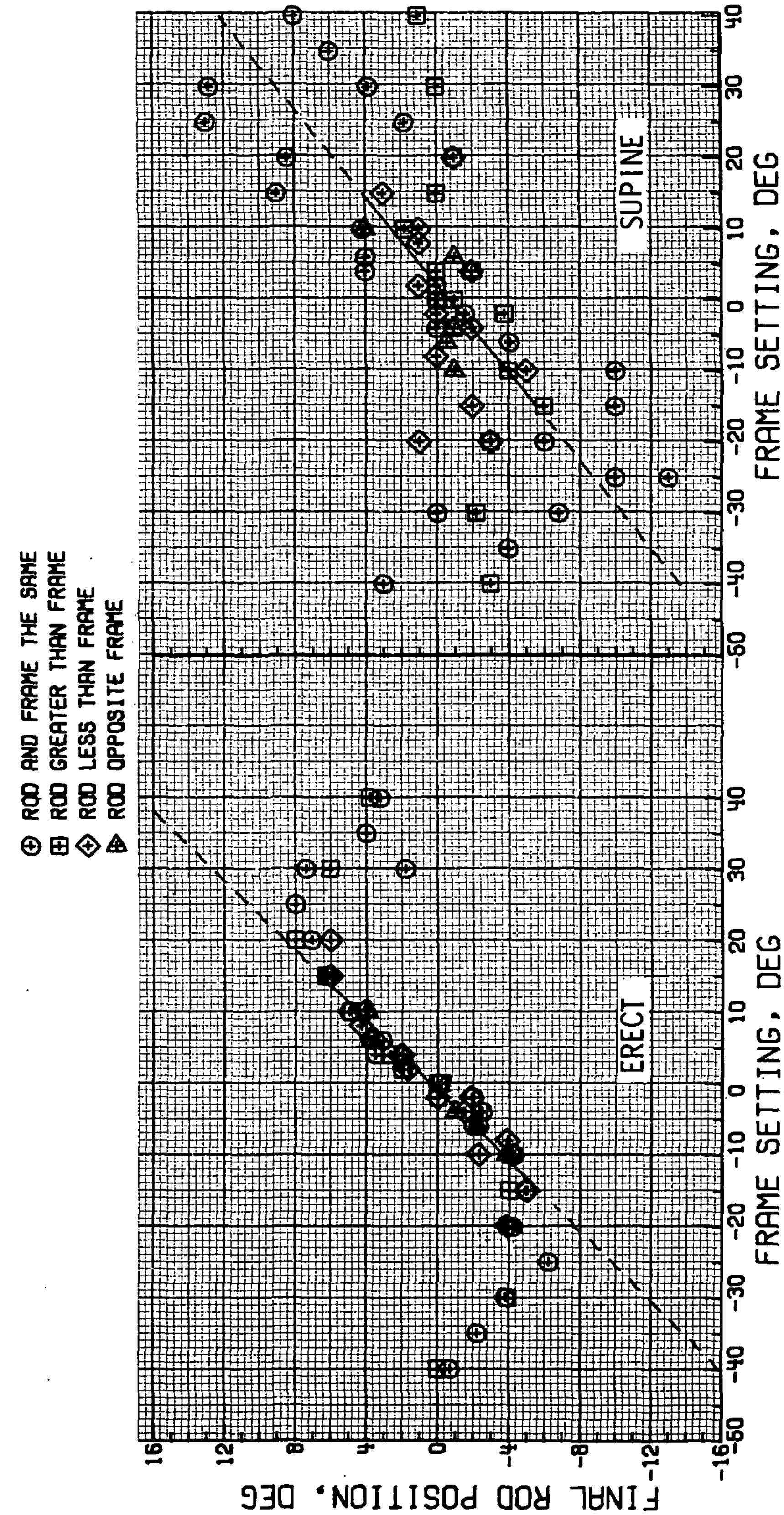


Figure A20.- Response data for subject 20.

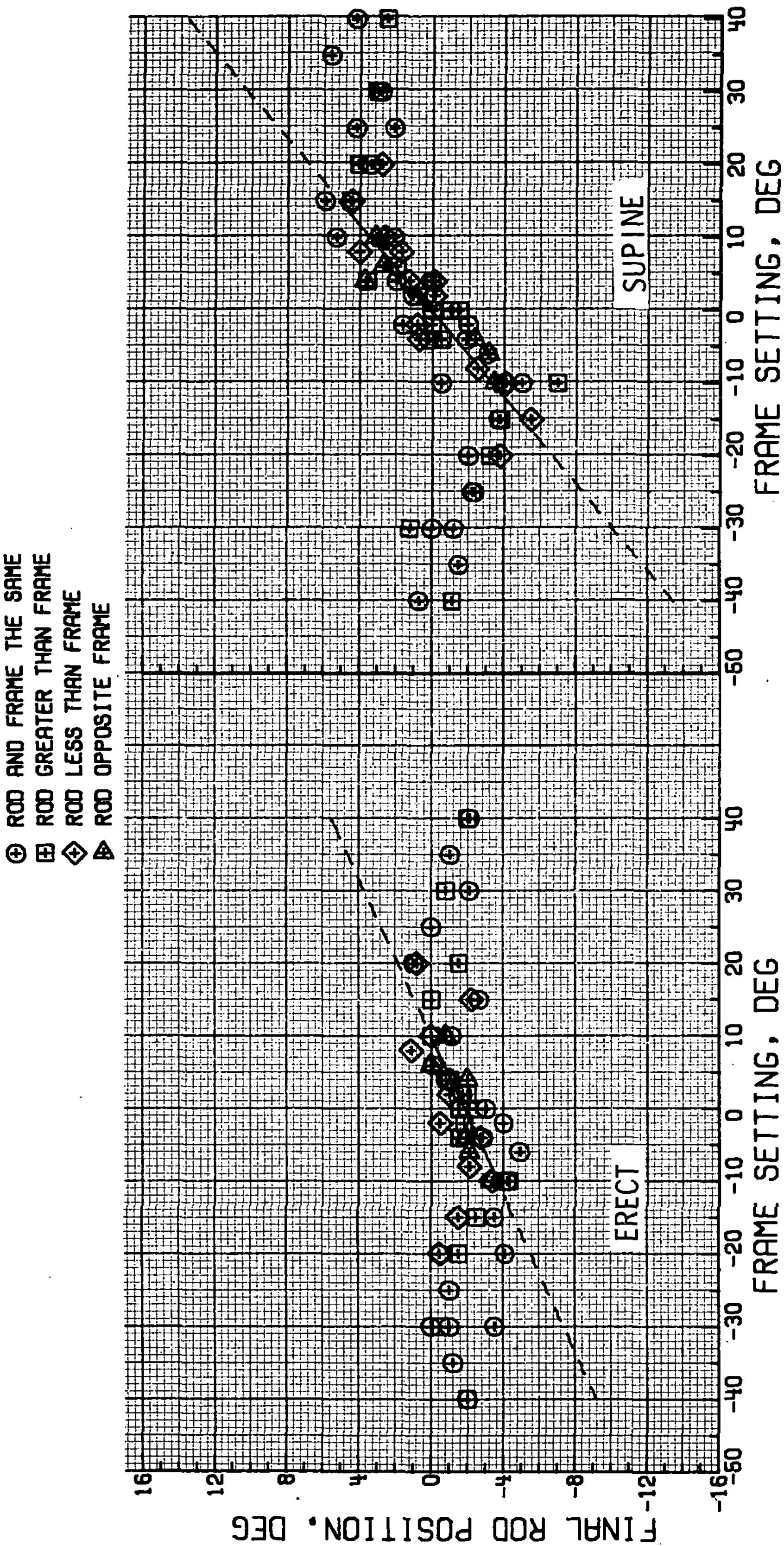


Figure A21.- Response data for subject 21.

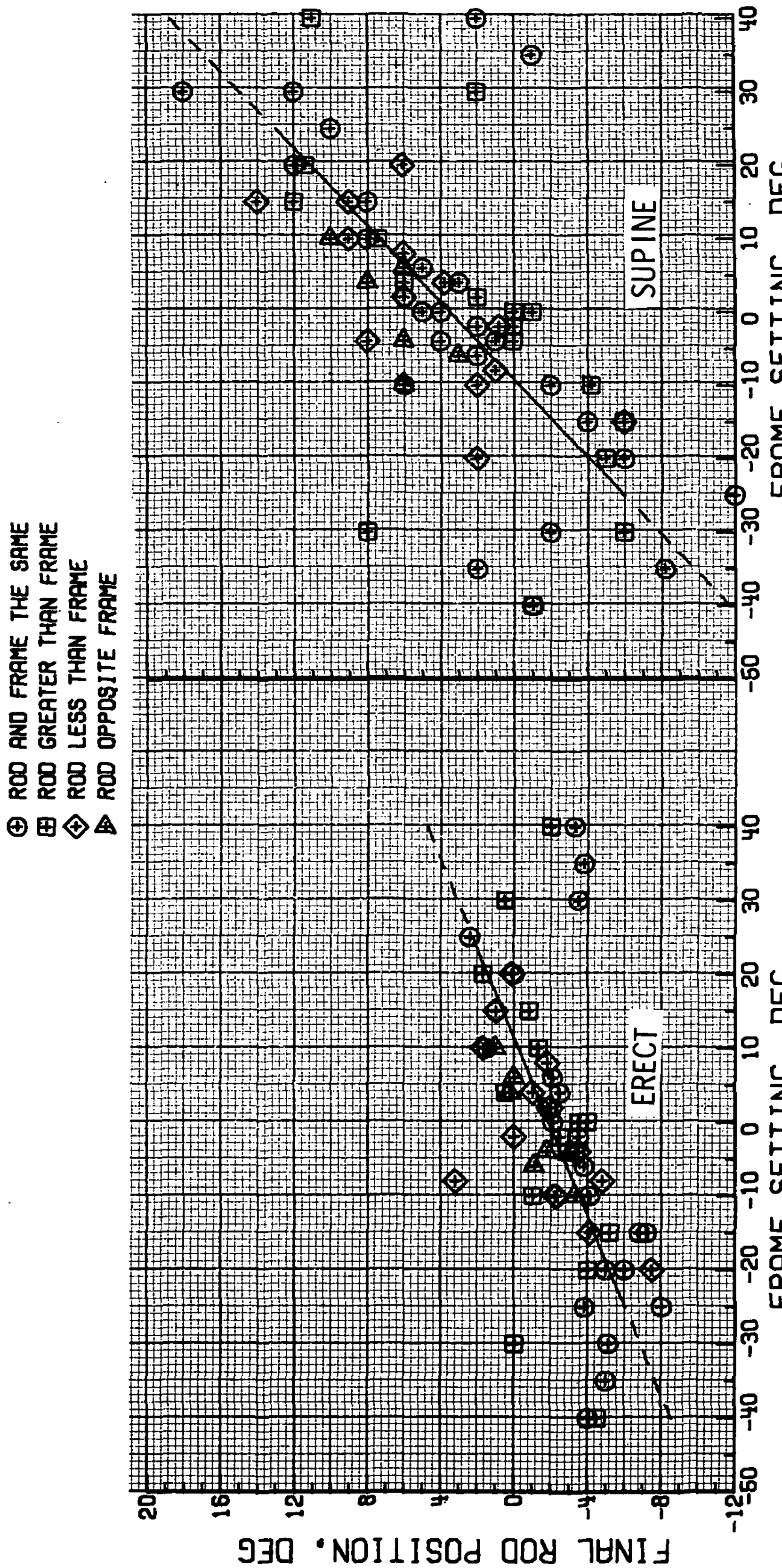


Figure A22.- Response data for subject 22.

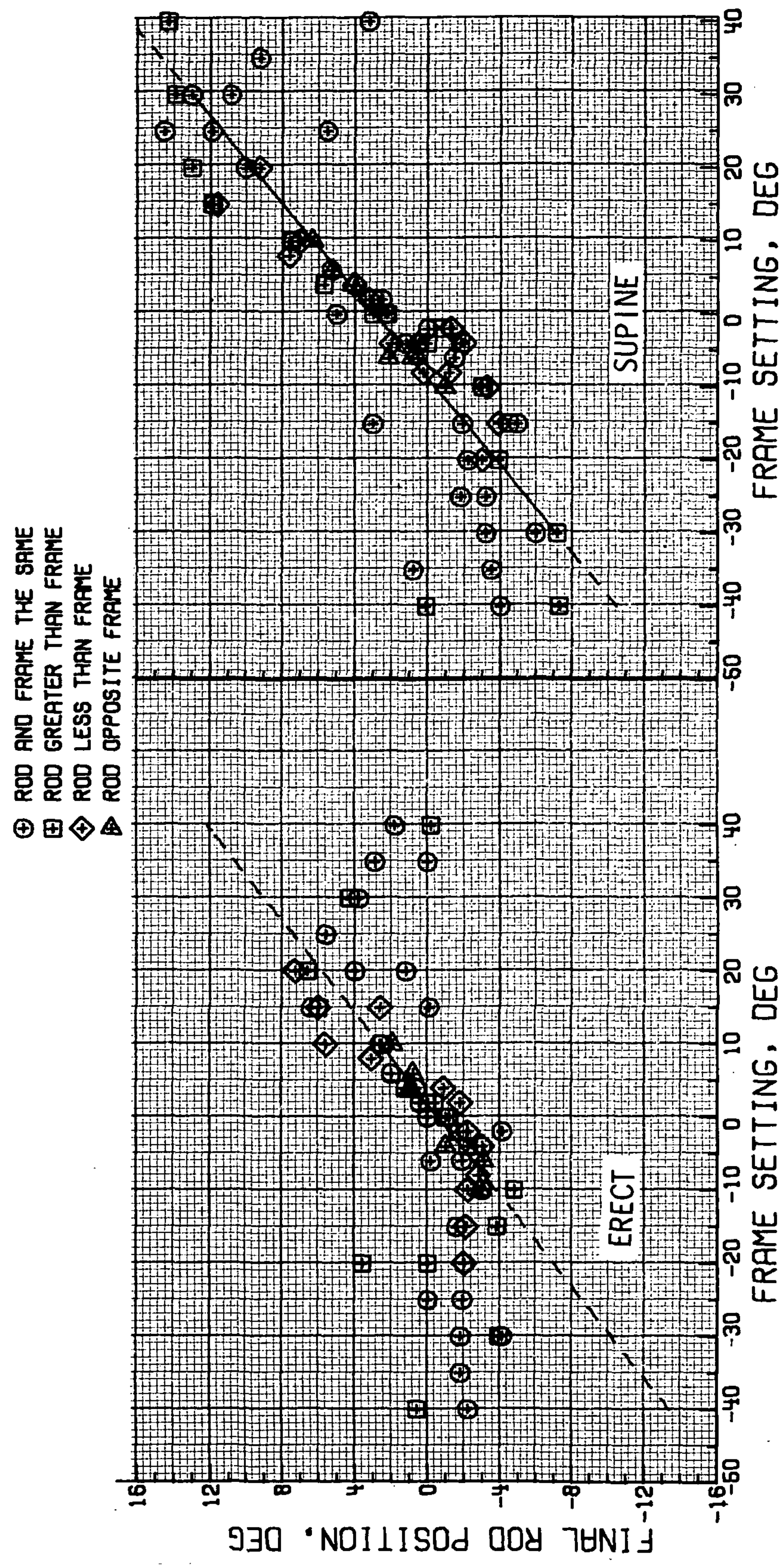


Figure A23.- Response data for subject 23.

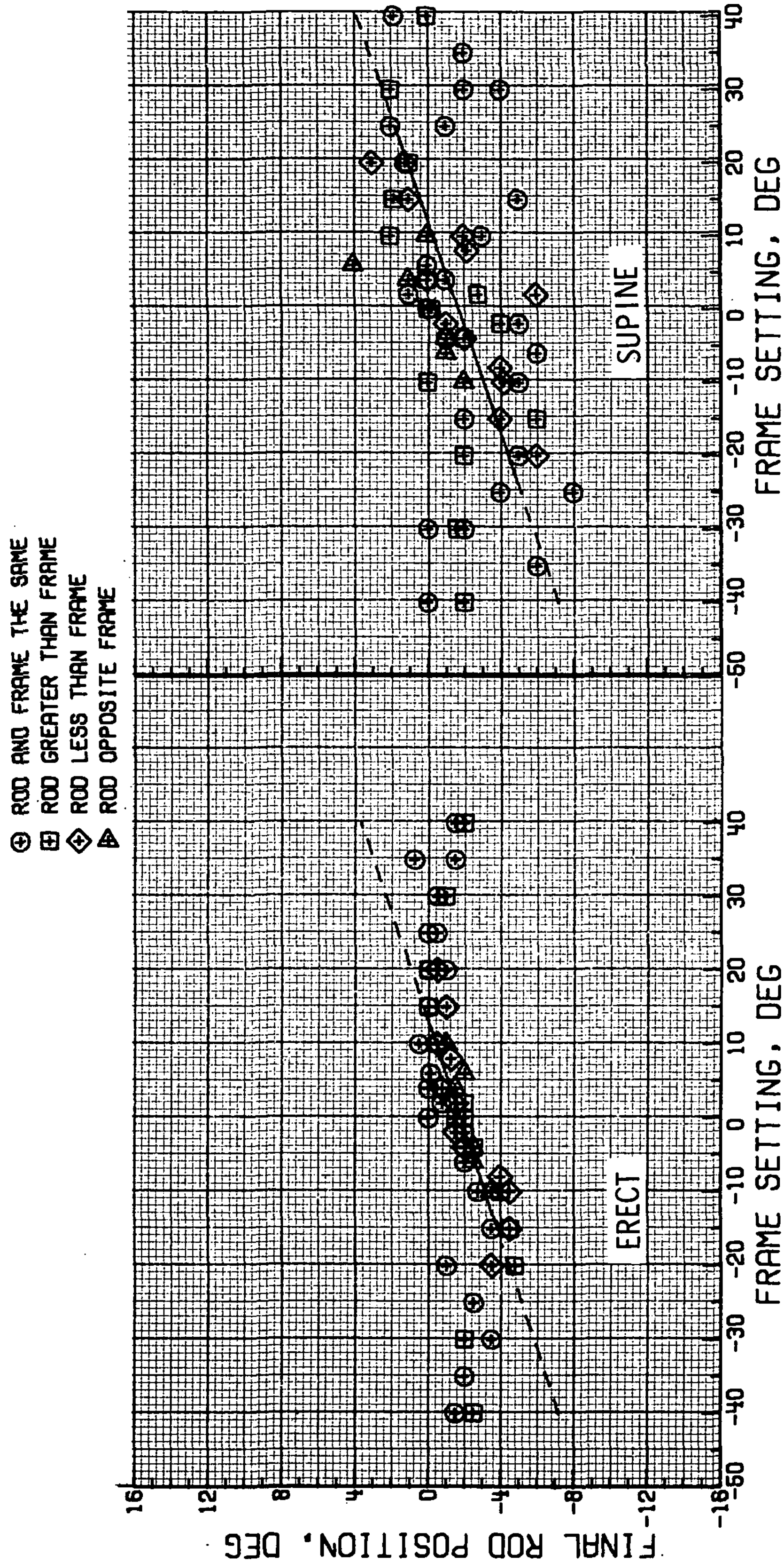


Figure A24.- Response data for subject 24.

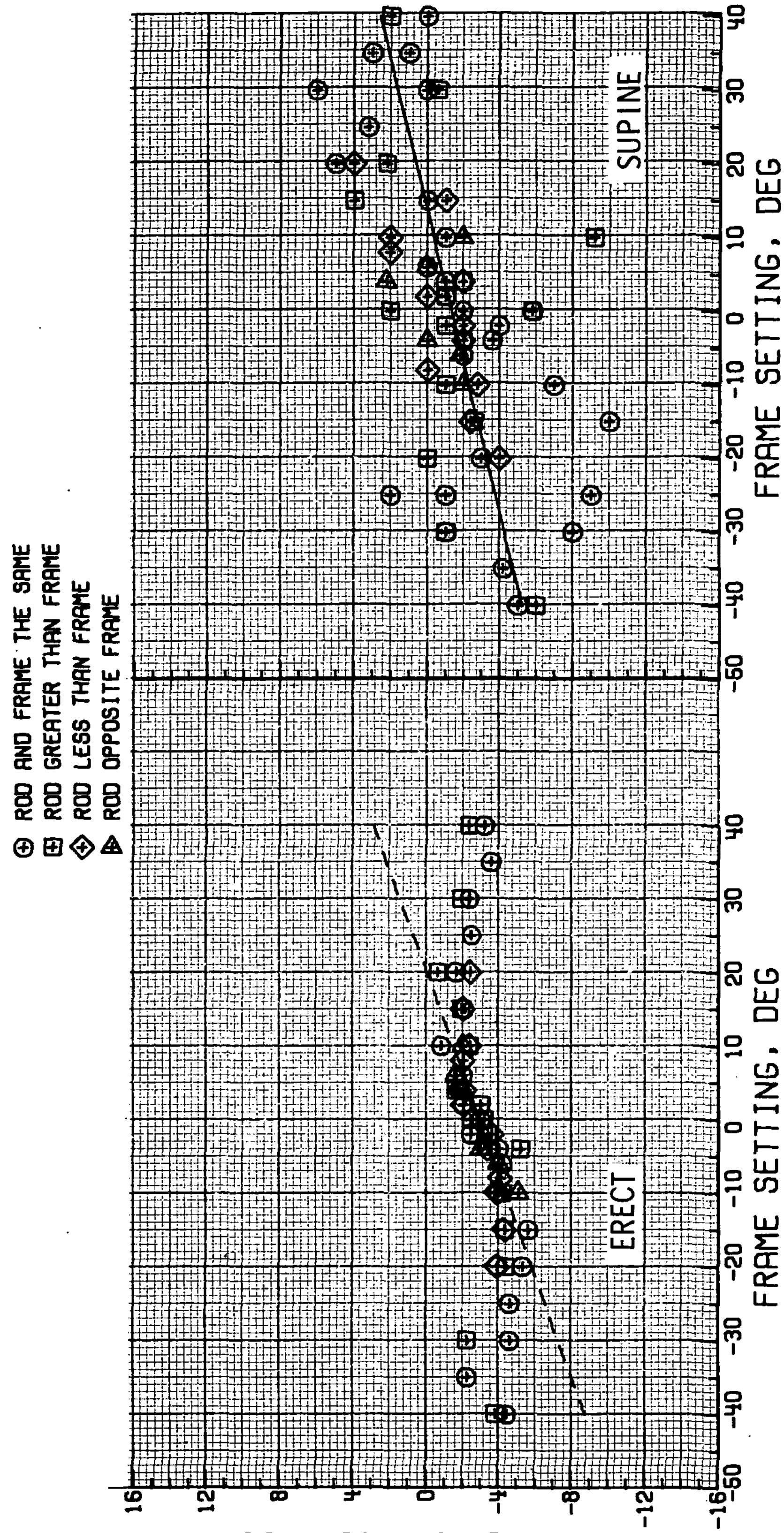


Figure A25.- Response data for subject 25.

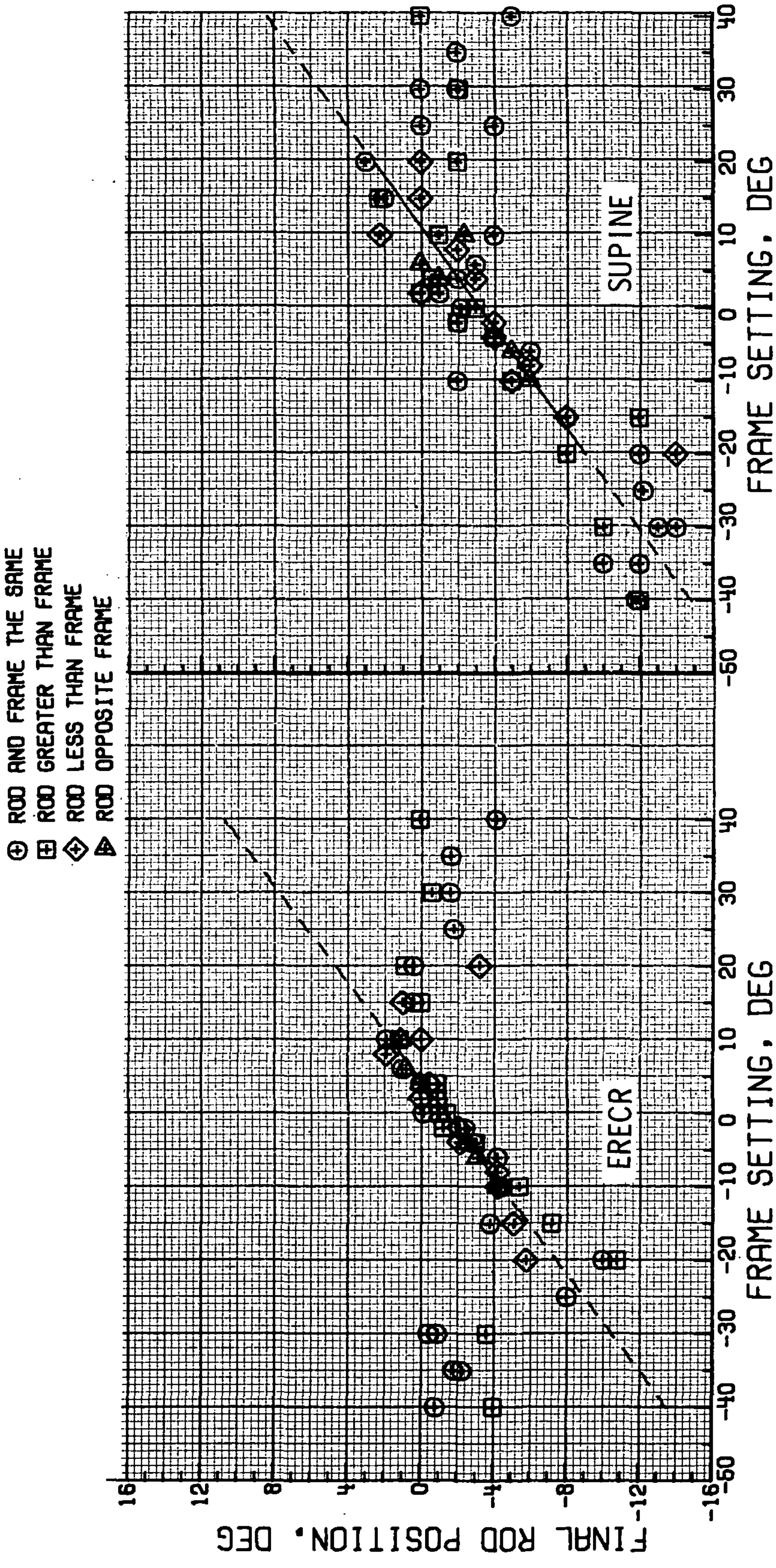


Figure A26.- Response data for subject 26.

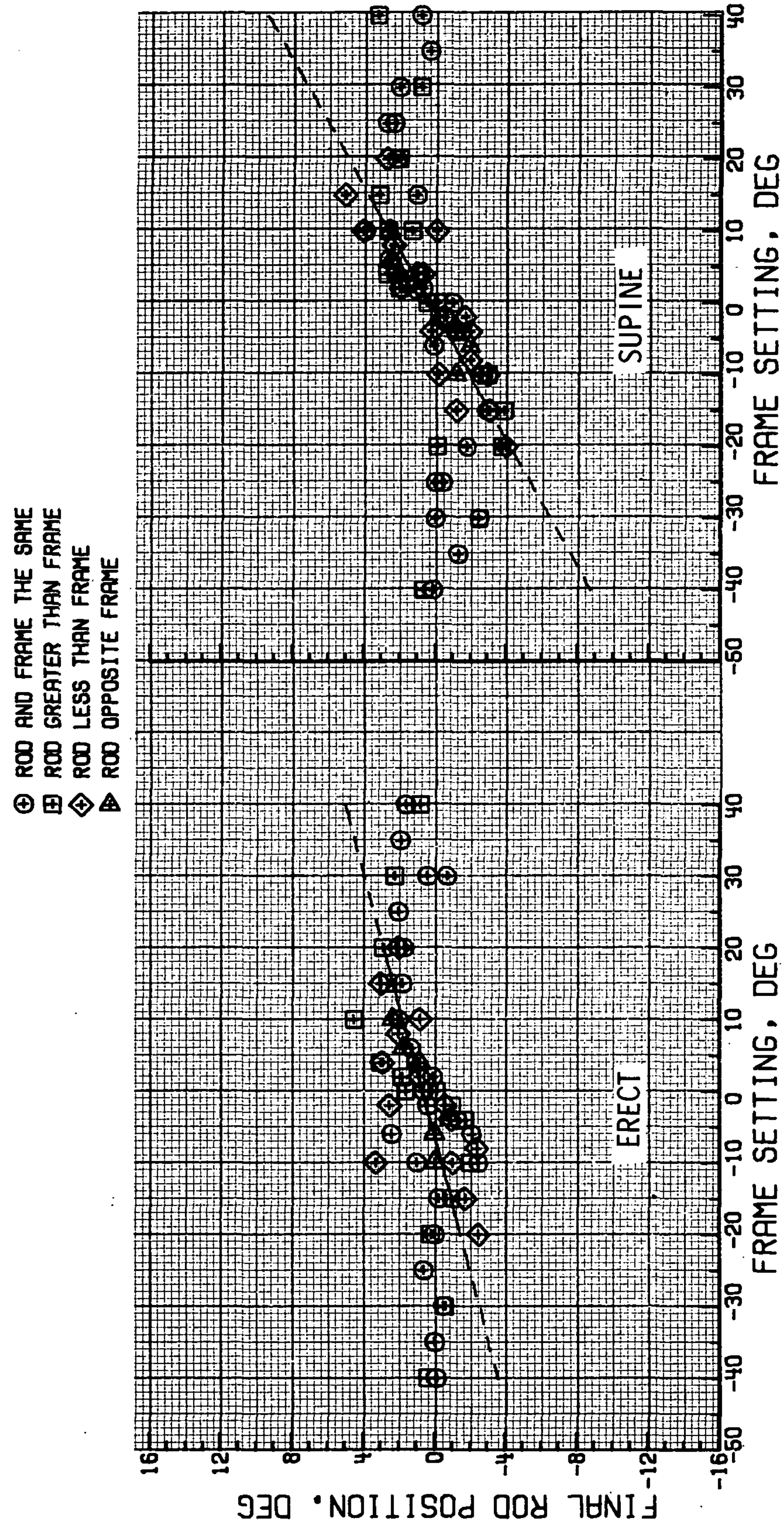


Figure A27.- Response data for subject 27.

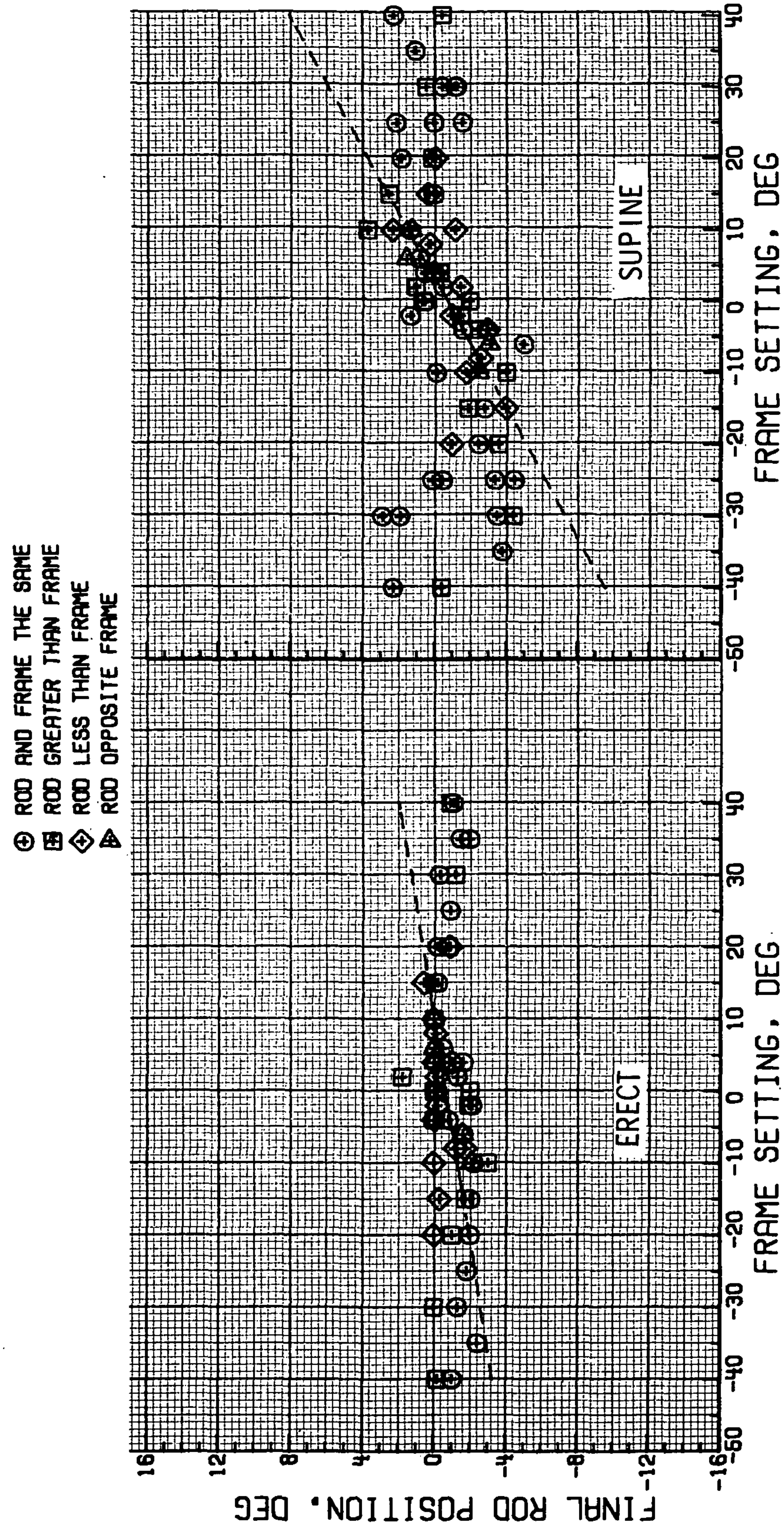


Figure A28.- Response data for subject 28.

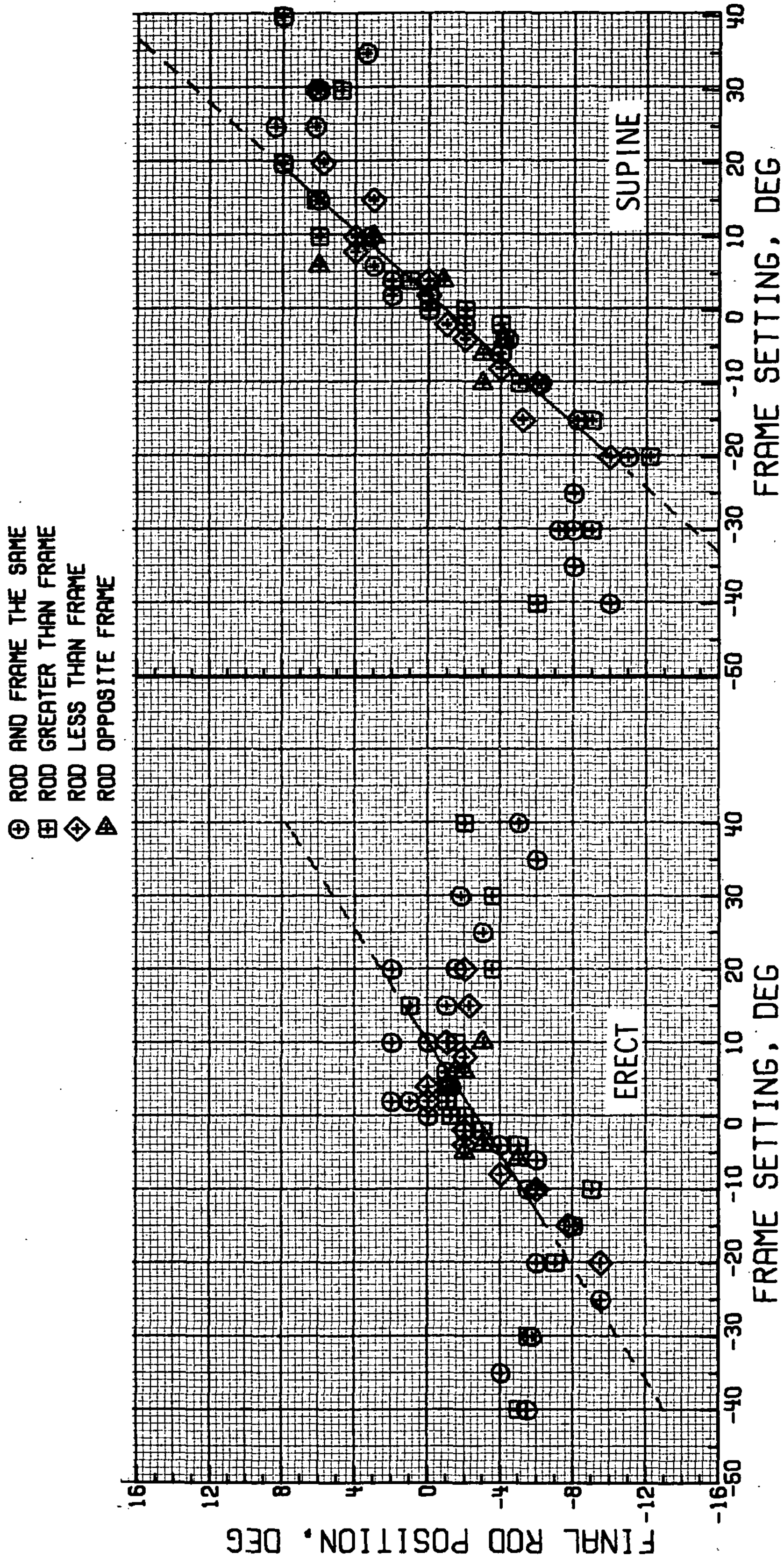


Figure A29.- Response data for subject 29.

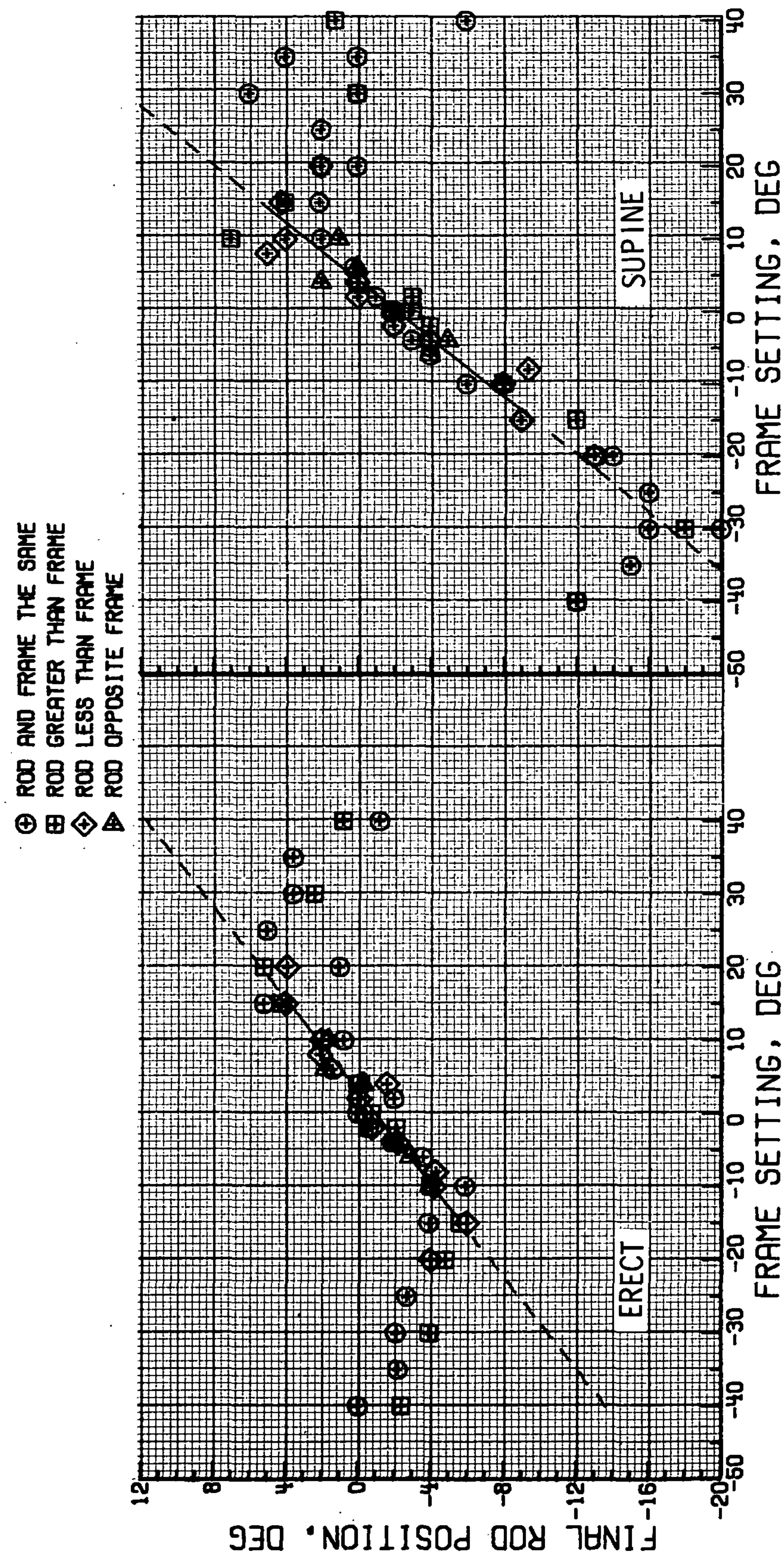


Figure A30.- Response data for subject 30.

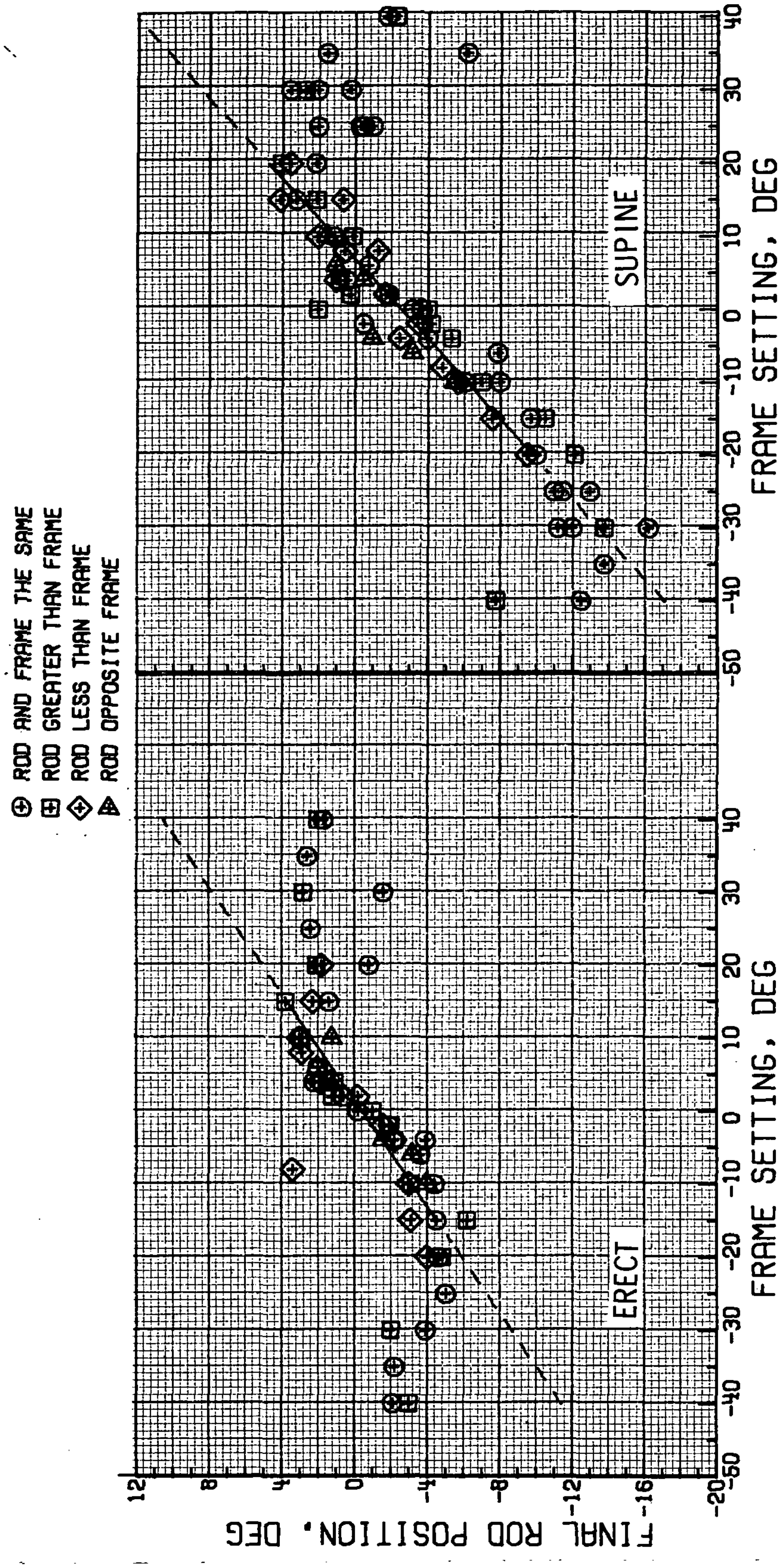


Figure A31.- Response data for subject 31.

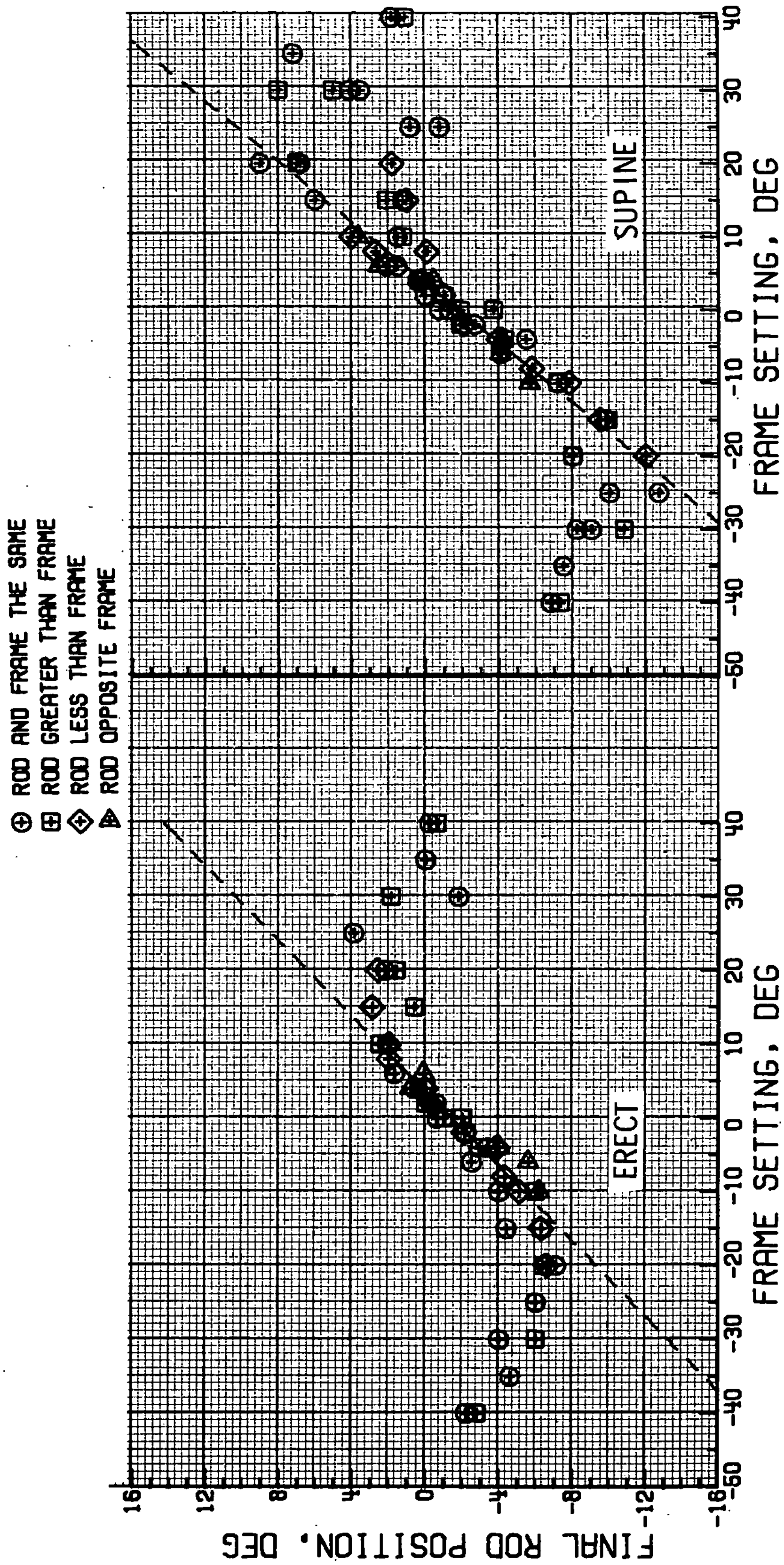


Figure A32.- Response data for subject 32.

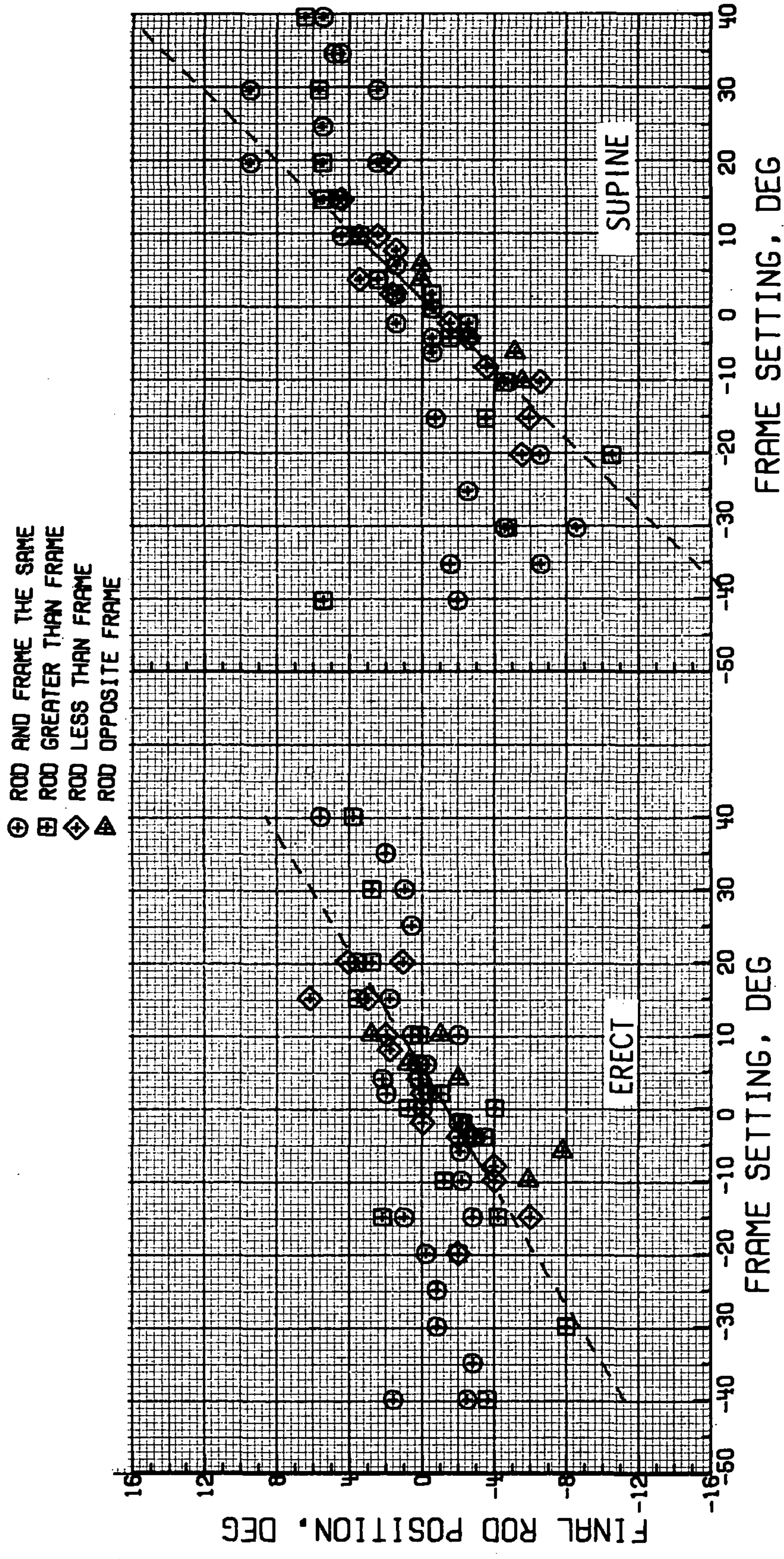


Figure A33.- Response data for subject 33.

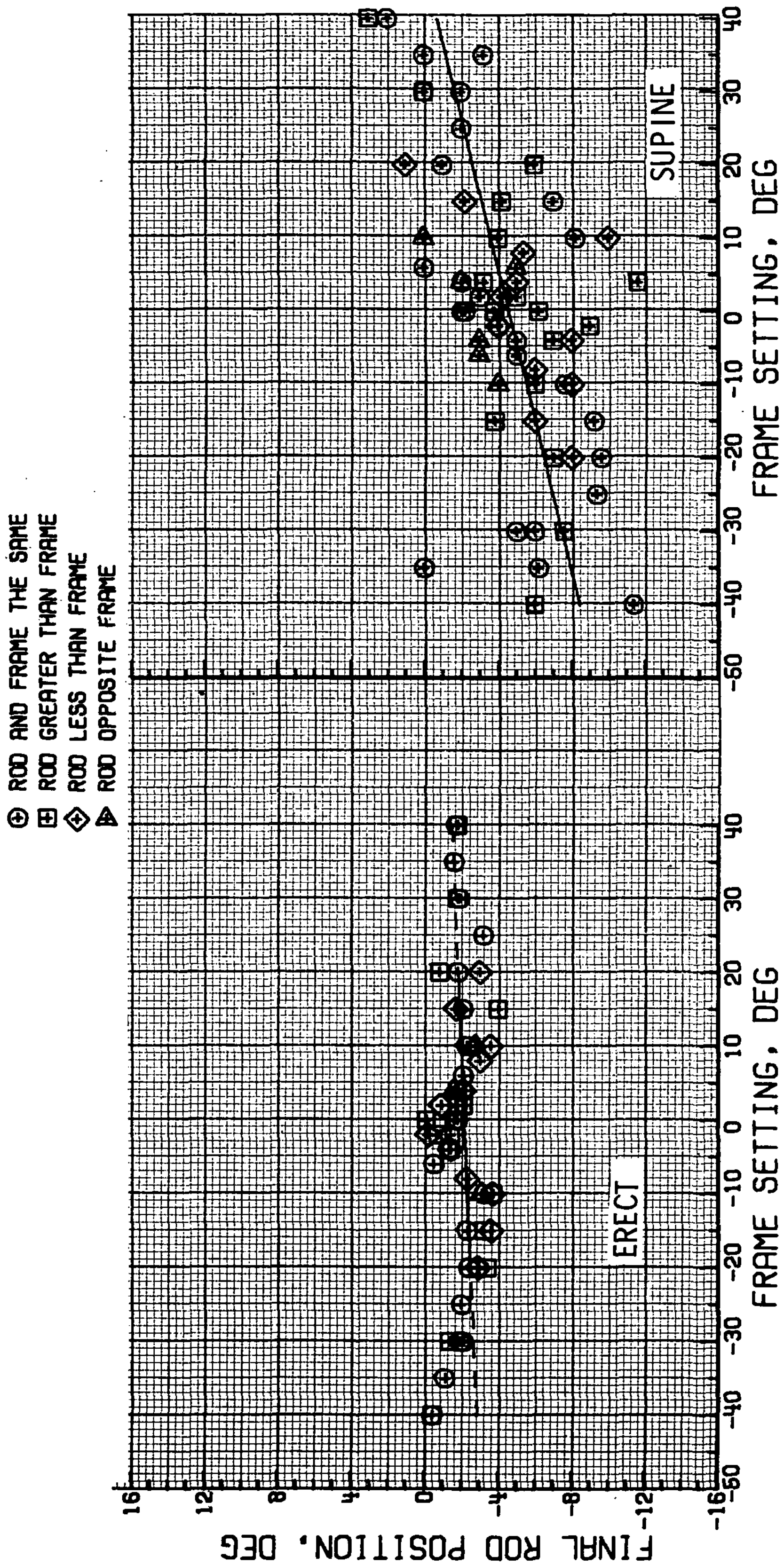


Figure A34.- Response data for subject 34.

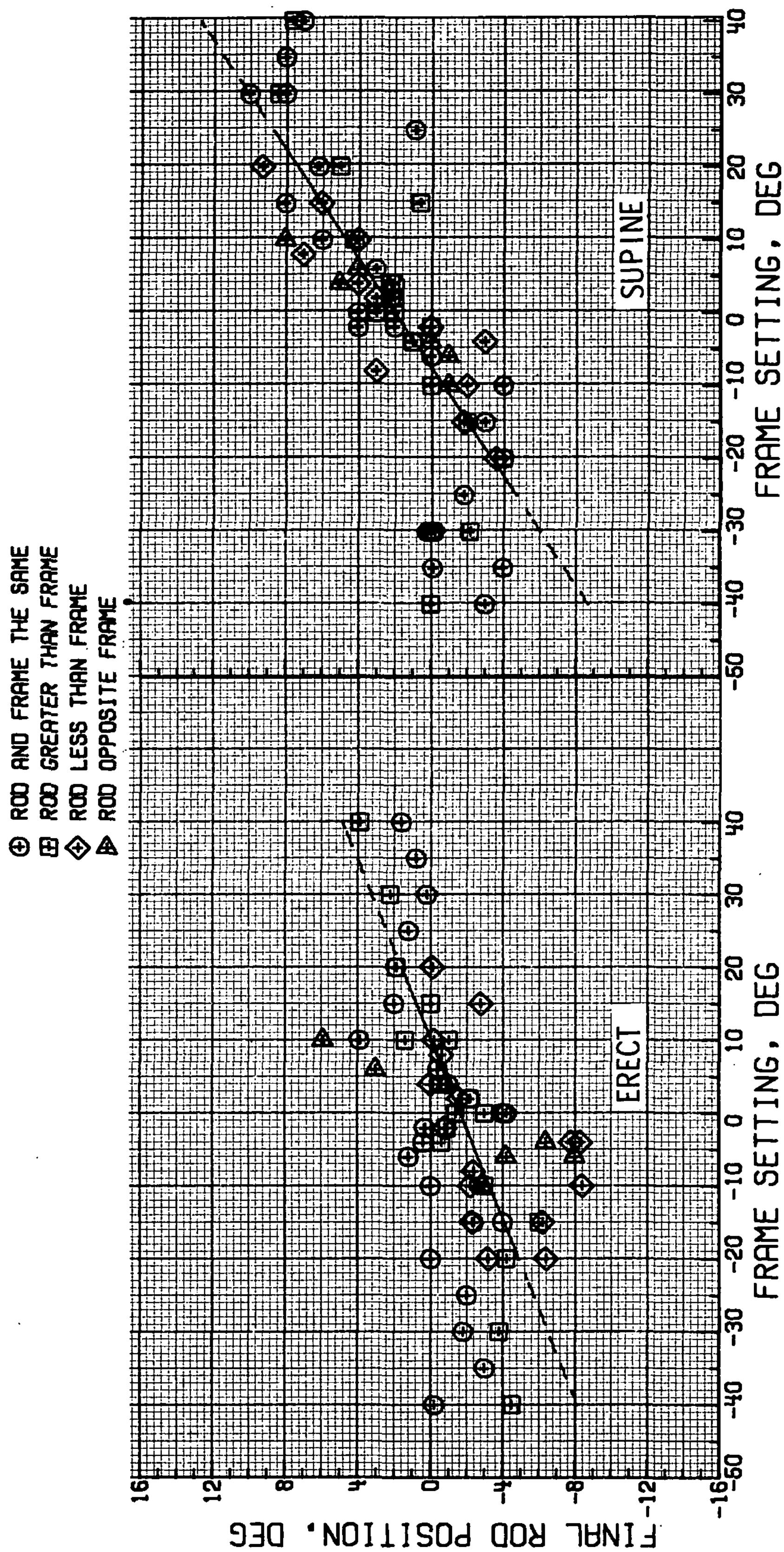


Figure A35.- Response data for subject 35.

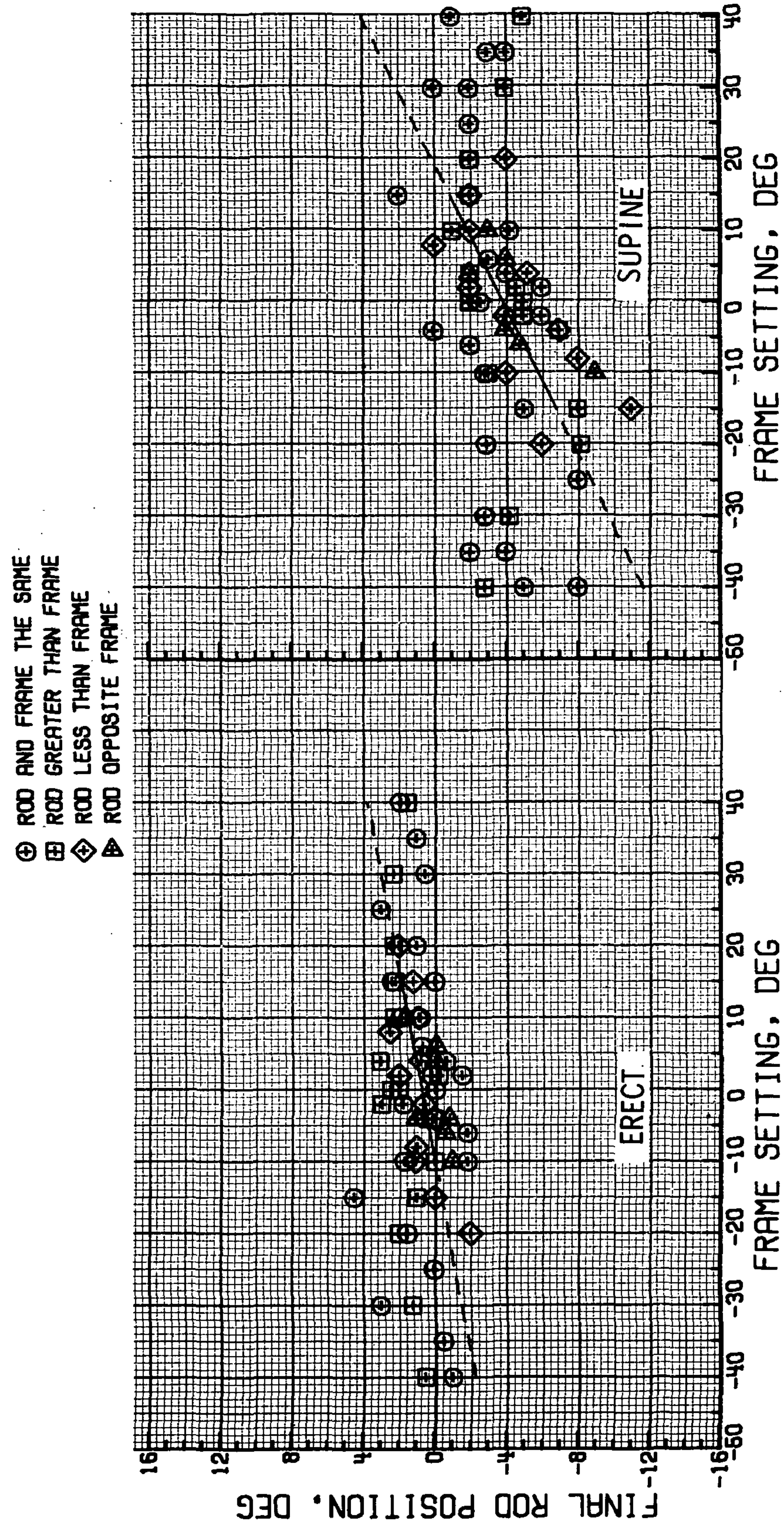


Figure A36.- Response data for subject 36.

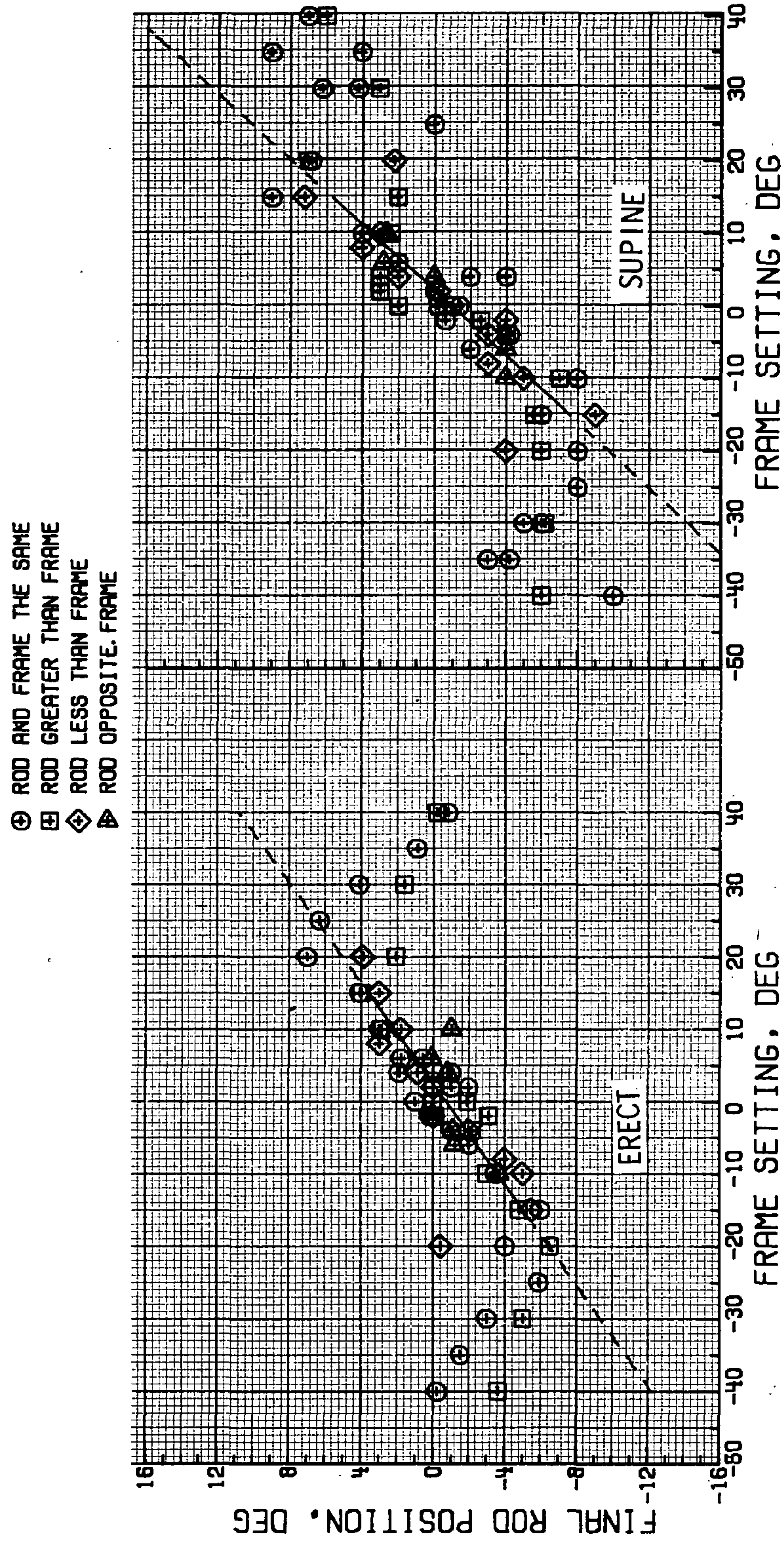


Figure A37.- Response data for subject 37.

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"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

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